INTRASEASONAL VARIABILITY

DUANE E. WALISER

Jet Propulsion Laboratory, MS 183-505
California Institute of Technology
4800 Oak Grove Drive, Pasadena, CA 91109, USA
E-mail: duane.waliser@jpl.nasa.gov

(Note: This review derives from a chapter being written for:*THE ASIAN MONSOON*-Chapter 5, Edited by Bin Wang)

5.1 Introduction

While the defining variability of a monsoon system is its seasonal character, its variability about its typical seasonal evolution is often of most interest and importance. In the case of the Asian and Australian summer monsoons, their intraseasonal character is especially prominent and unique.

Figure 1 compares annual rainfall variability along with the interannual and intraseasonal variability (ISV) for the Northern and Southern Hemisphere summer seasons. The annual standard deviation exhibits strong variability on either side of the equator, which is a depiction of the annual meridional migration of the tropical rainfall band – a fundamental manifestation of the monsoon. The maps of interannual variability, particularly that for boreal winter, emphasize the connection to ENSO-related SST variability in the tropical Pacific Ocean. These maps of ISV illustrate two important features. First, the intraseasonal rainfall variability is as large or larger than the variability associated with the other time scales illustrated. Second, it tends to be relatively most prominent in the Asian and Australian monsoon sectors. The time series in Figure 2 show the annual cycle of rainfall and the anomalous evolution of unfiltered and filtered rainfall over India and northern Australia for a sample of three years. These time series emphasize the overall dominance, apart from the annual variation, of the intraseasonal time scale on these monsoon systems, including its obvious role in dictating onset and break phases. Even from these simple diagnostic figures, it is evident that ISV is a fundamental component of these monsoon systems.

The material in this chapter is devoted to describing the ISV associated with the Asian, and to some extent the Australian, summer monsoon. This includes the role it plays in the monsoons' onsets and breaks, its seasonal evolution, its interannual and decadal variability and remote influences. In addition, the chapter will discuss what is understood regarding the important physical processes associated with monsoon ISV as well as our present capabilities and shortcomings in simulating and predicting it. While this book as a whole is devoted to the Asian monsoon, the treatment of ISV cannot be readily isolated to the boreal summer alone. The scientific developments associated with tropical ISV, including the observational and theoretical underpinnings as well as process-oriented modeling studies, have drawn from parallel, related and/or comprehensive studies on both boreal summer and boreal winter manifestations. For this reason, much of this chapter necessarily involves review material associated with boreal summer (e.g. Asian summer monsoon) and boreal winter (e.g. Australian summer monsoon). Where possible and appropriate, the discussion will be more tightly isolated to the Asian summer monsoon alone [e.g., 10-30 day variability, climatological intraseasonal oscillation (ISO), teleconnections]. Note that more thorough reviews of a number of the topics discussed in this chapter can be found in Lau and Waliser (2004).

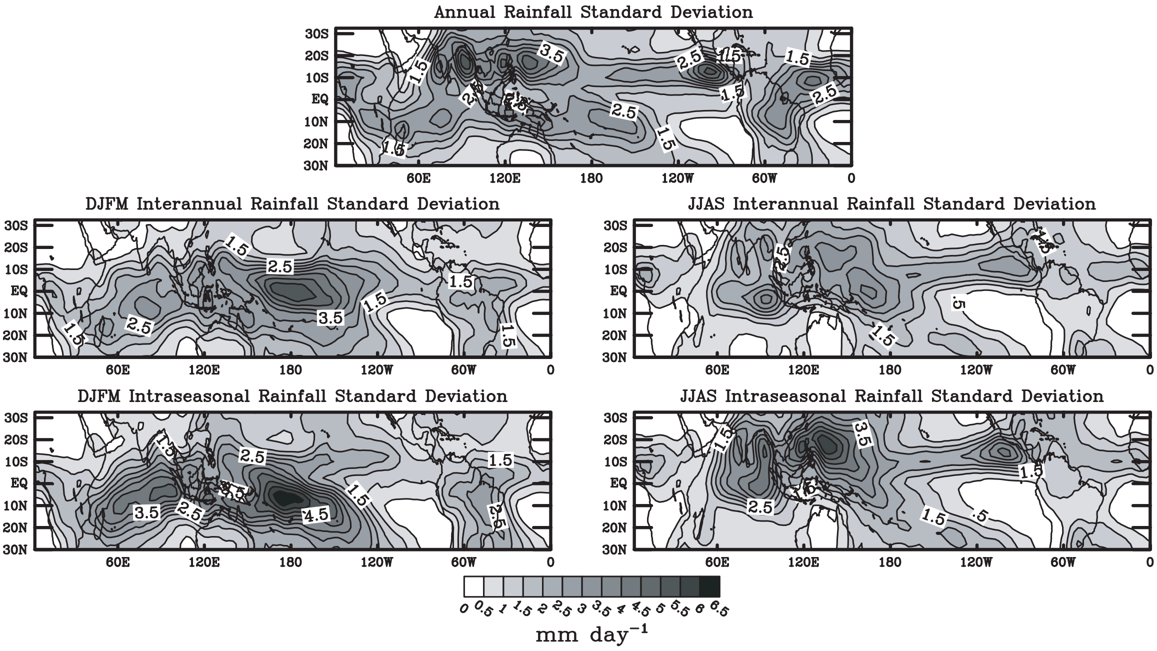


Figure 1. Rainfall variability maps for the global tropics. Rainfall data is based on pentad values of the satellite and in-situ merged CMAP product of Xie and Arkin (1997) from 1979 to 1999. (upper) Annual cycle. In this case, the mean 73-pentad annual cycle was constructed from the data and the variance was computed about the annual mean; values shown in terms of standard deviation. (middle) Interannual variability. In this case, the data were low-pass filtered, retaining periods longer than 90 days. The variance of these interannual anomalies was computed for the December-March (left) and June-September (right) periods separately; values shown in terms of standard deviation. (lower) ISV. In this case, the data were band-pass filtered, retaining periods between 30 and 90 days. The variance of these intraseasonal anomalies was computed for the December-March (left) and June-September (right) periods separately; values shown in terms of standard deviation.

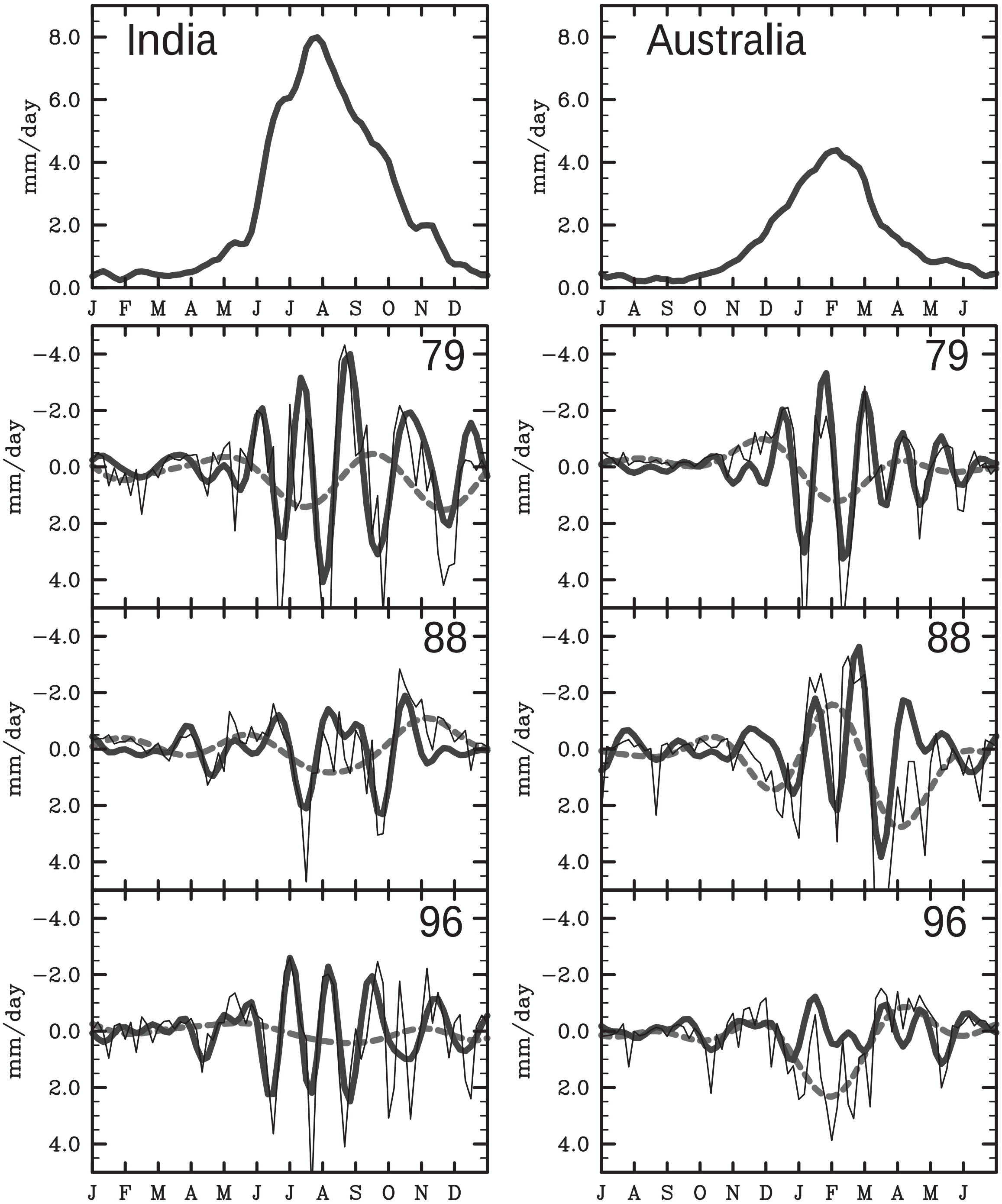


Figure 2. Time series of rainfall over India (left) and Australia (right). Rainfall data is based on pentad values of the satellite and in-situ merged CMAP product of Xie and Arkin (1997) from 1979 to 1999. The data plotted for India (Australia) are the domain averages of the grid points lying within India (Australia, lying north of 25^{o}S). (top) Mean 73-pentad annual cycle. (lower three panels) The thin black lines are pentad anomaly values, the thick black lines are 30-90 day band-passed values, and the thick dashed lines are 90 day low-pass values for the years 1979, 1988 and 1996.

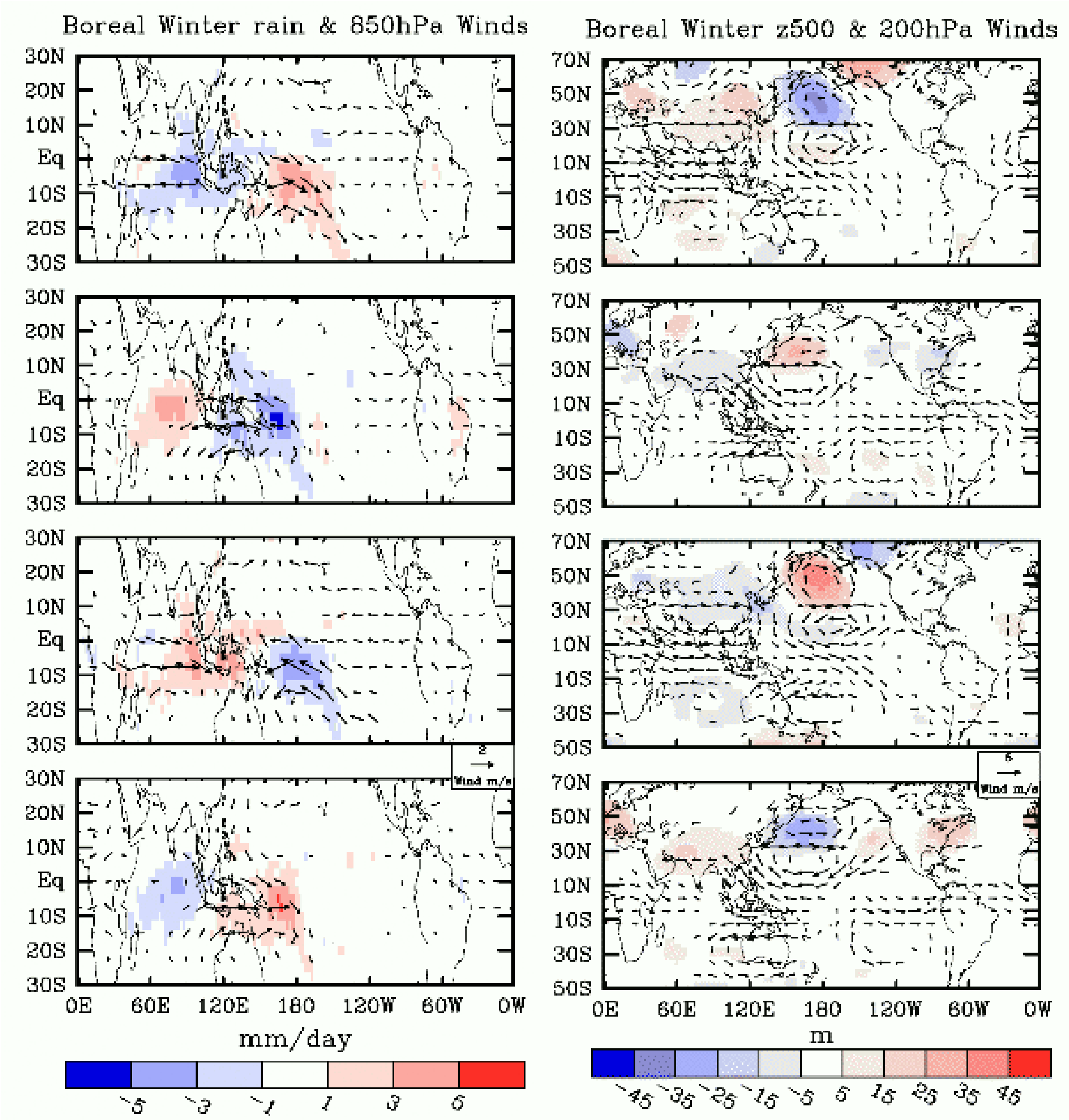


Figure 3. Canonical structure of an MJO event based on 5-day average (i.e. pentad) NCEP/NCAR Reanalysis (Kalnay *et al.*, 1996) and CMAP rainfall data (Xie and Arkin, 1997) from 1979-2000. Data were bandpassed filtered with a 30-90 day filter and then separated into boreal winter (Nov-Apr) and summer (May-Oct). Extended EOF (EEOF) analysis with +/-5 pentad lags was performed on tropical rainfall (30N-30S, 30E to 180E) to identify the dominant "mode" for the winter and summer separately. Composite events were constructed by selecting events if the EEOF amplitude time series exceeded 1 standard deviation [N = 43 (49) for winter (summer)]. The resulting composites have dimensions lag (-5 to +5 pentads), latitude and longitude. In the plots above, only 4 panels of the boreal winter composite are shown, each separated by 2.5 pentads (i.e. 12.5 days). Plots on the left show composite rainfall and 850 hPa wind vectors between 30N and 30S. Plots on the right show 500 hPa geopotential heights and 200 hPa wind vectors between 30N and 30S. Only values that exceed the 90% confidence limit are shown.

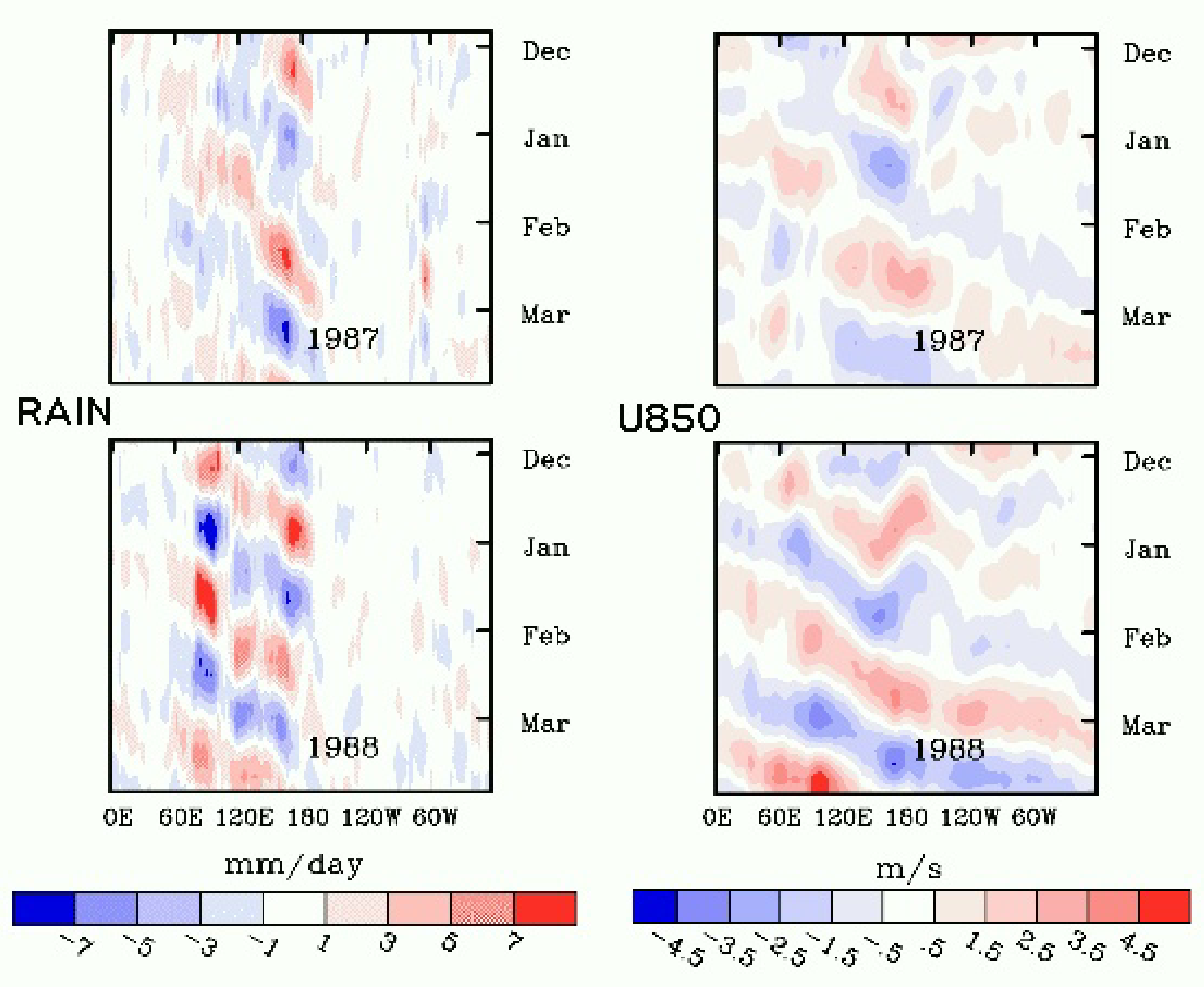


Figure 4. Time-longitude diagrams of 30-90 day bandpass filtered (left) CMAP rainfall data (Xie and Arkin, 1997) and (right) NCEP/NCAR Reanalysis 850 hPa zonal winds (Kalnay *et al.*, 1996) for the winters of 1986-87 and 1987-88. Data were averaged between 10N and 10S.

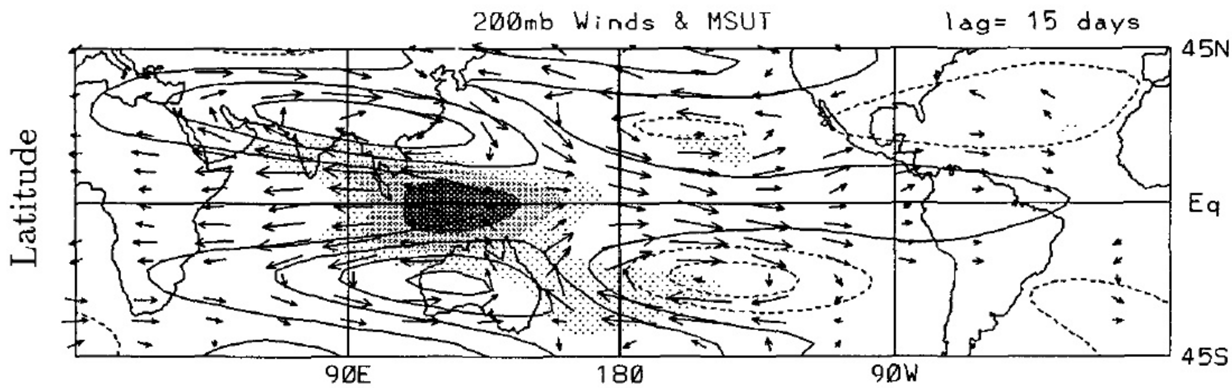


Figure 5. Longitude-latitude map for a composite MJO event 15 days after positive rainfall anomaly passed over 85°E. Vectors are 200 hPa winds anomalies, contours are MSU Channel 2 temperature anomalies, and shadings are OLR anomalies. Data were bandpass filtered to eastward wavenumbers 1-3 and 35-95 day periods. Maximum vectors are 2.7 m s^{-1} and temperature contours are 7.0 x 10^{-2} K. OLR is converted to equivalent blackbody temperatures and the shading starts at 0.5 K and change every 1.25 K, with positive values indicating enhanced convection. From Hendon and Salby (1994).

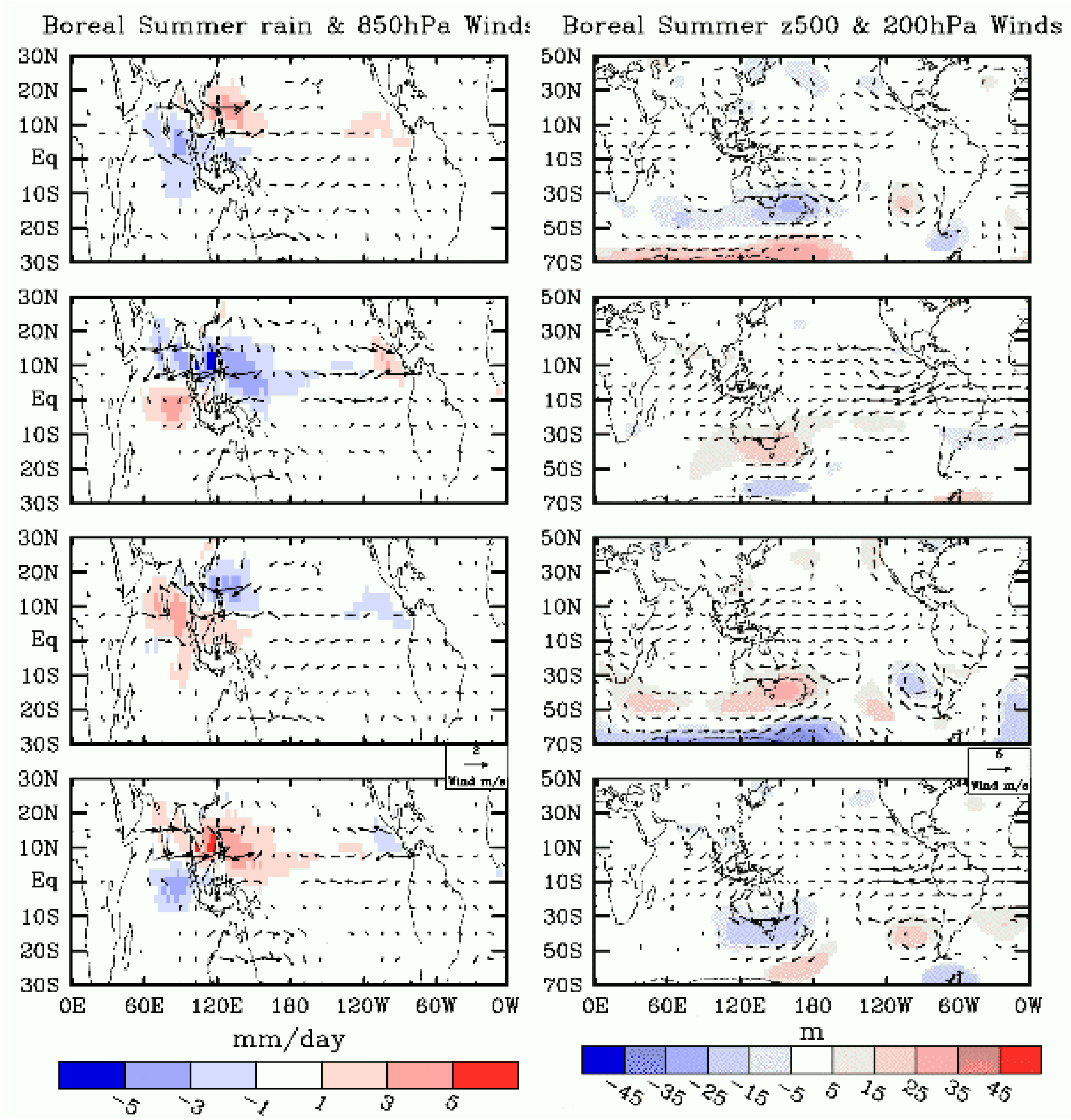


Figure 6. Same as

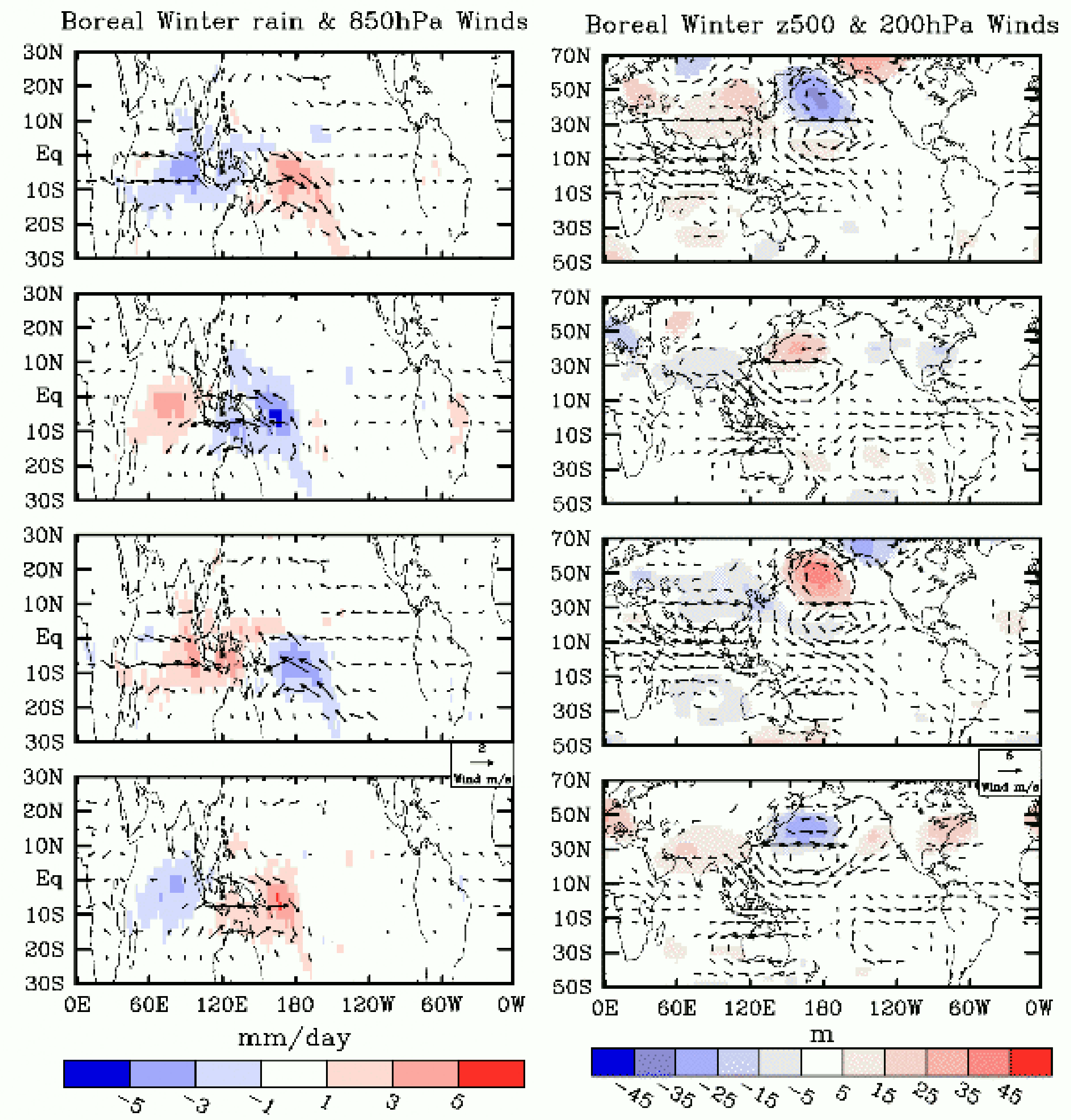


Figure 3, except for boreal summer (May-Oct).

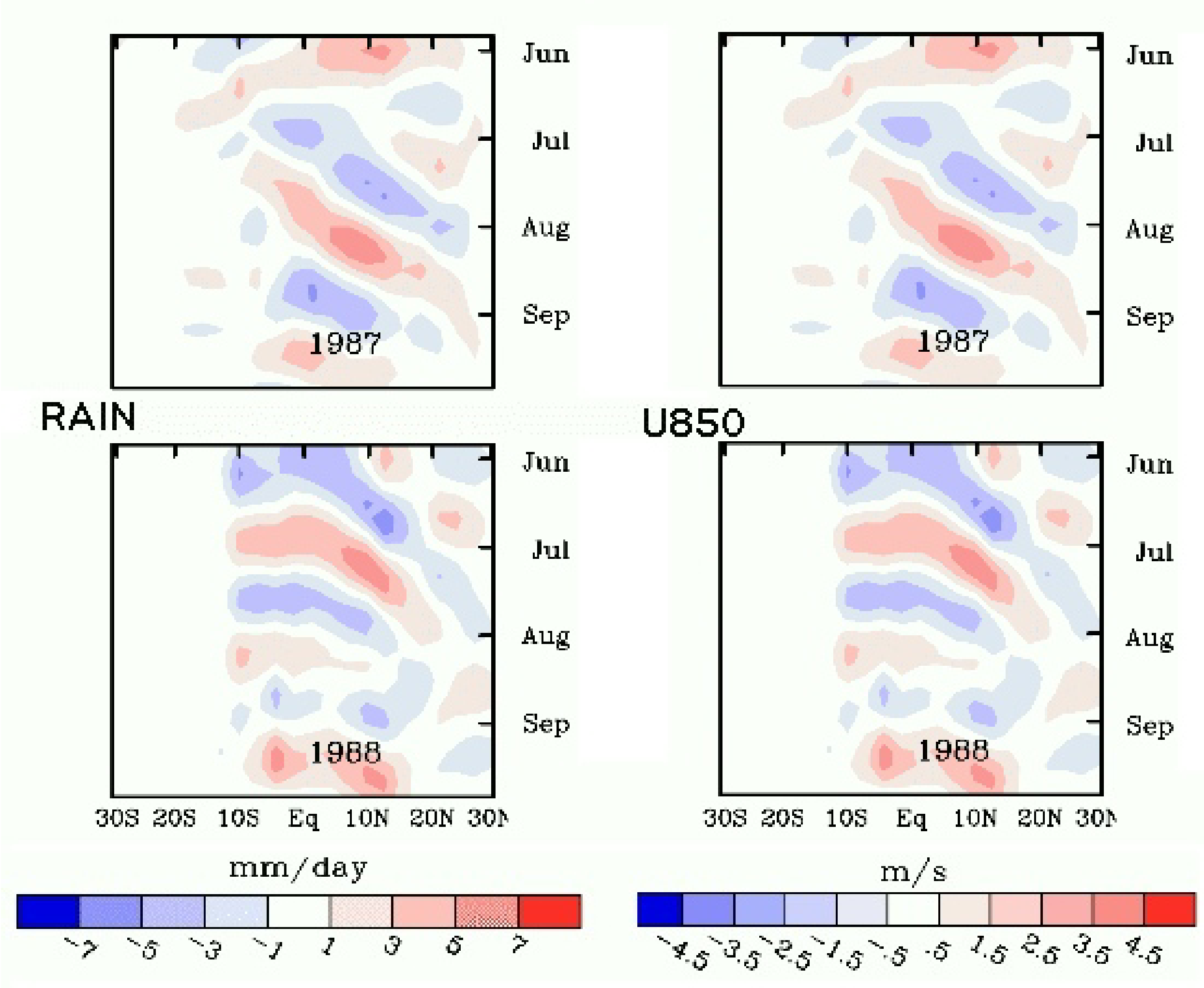


Figure 7. Time-latitude diagrams of 30-90 day bandpass filtered (left) CMAP rainfall data (Xie and Arkin, 1997) and (right) NCEP/NCAR Reanalysis 850 hPa zonal winds (Kalnay *et al.*, 1996) for the summers of 1987 and 1988. Data were averaged between 80E and 110E. .

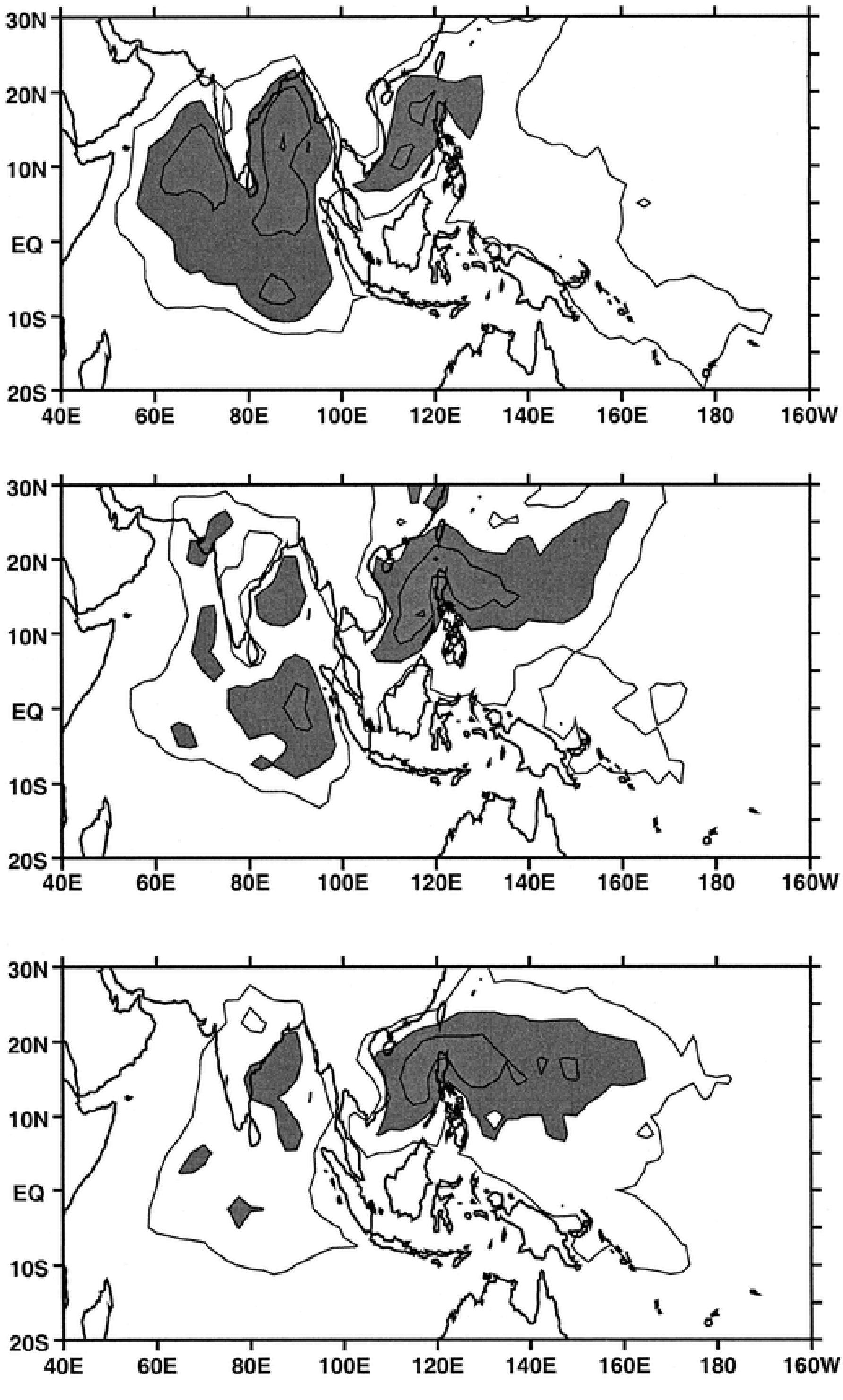


Figure 8. Seasonal variation of 10–100-day filtered OLR variance. (top) May–Jun average, (middle) Jul average, and (bottom) Aug–Oct average. Contour interval is 250 (W m^{-2})^2. First contour at 500 (W m^{-2})^2. Regions where the OLR variance > 750 (W m^{-2})^2 are shaded. From Kemball-Cook and Wang (2001).

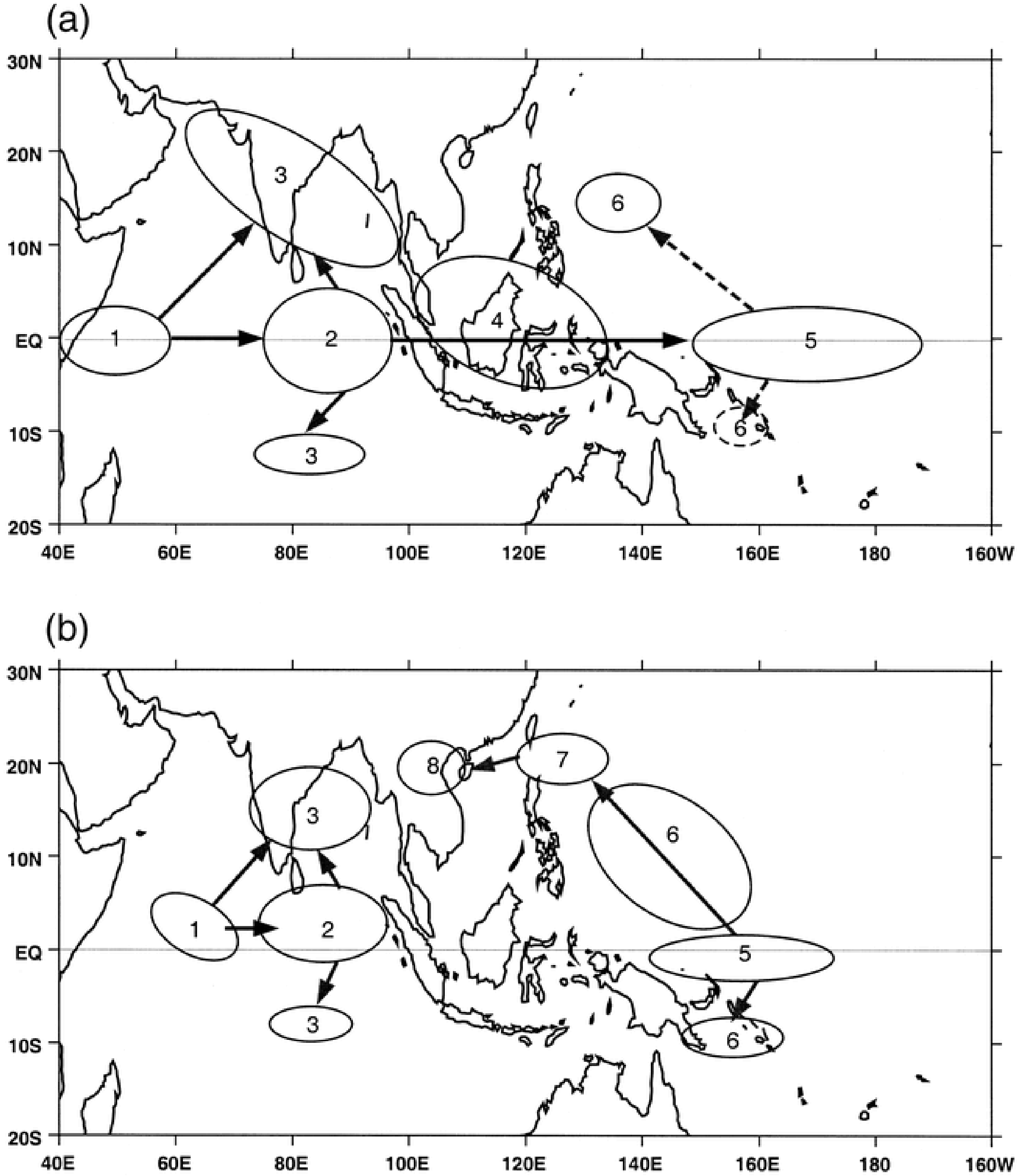


Figure 9. Boreal summer ISO convection life-cycle for (a) May–Jun and (b) Aug–Oct (Kemball-Cook and Wang, 2001). Ovals indicate convection, with numbers indicating the evolution of the anomaly. Horizontal arrows indicate eastward propagation of convection along or near the equator. Vertical/slanted arrows indicate poleward propagation of convection due to emanation of Rossby waves from equatorial convection. Dashed lines indicate low-amplitude signal.

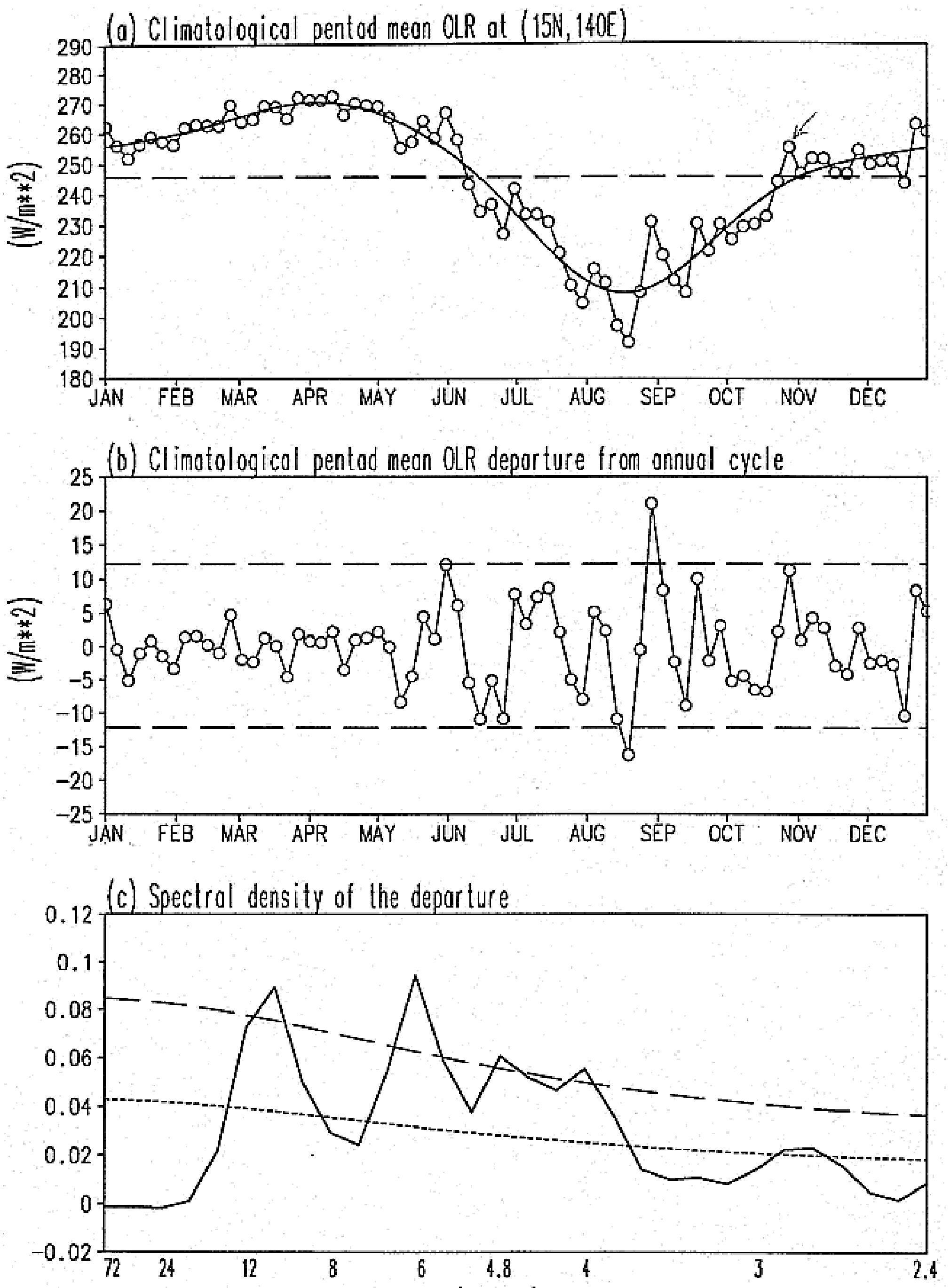


Figure 10. (a) Climatological pentad mean OLR at 15°N, 140°E and the base annual cycle (heavy line) defined by the sum of its first four Fourier harmonics. (b) The climatological pentad mean OLR departure from the base annual cycle. The dashed lines show the upper and lower bounds of the mean plus two standard deviations. (c) The spectral density of the departure. The dashed and dotted lines denote the upper and lower bounds of the 95% confidence interval against a red noise background. From Wang and Xu (1997).

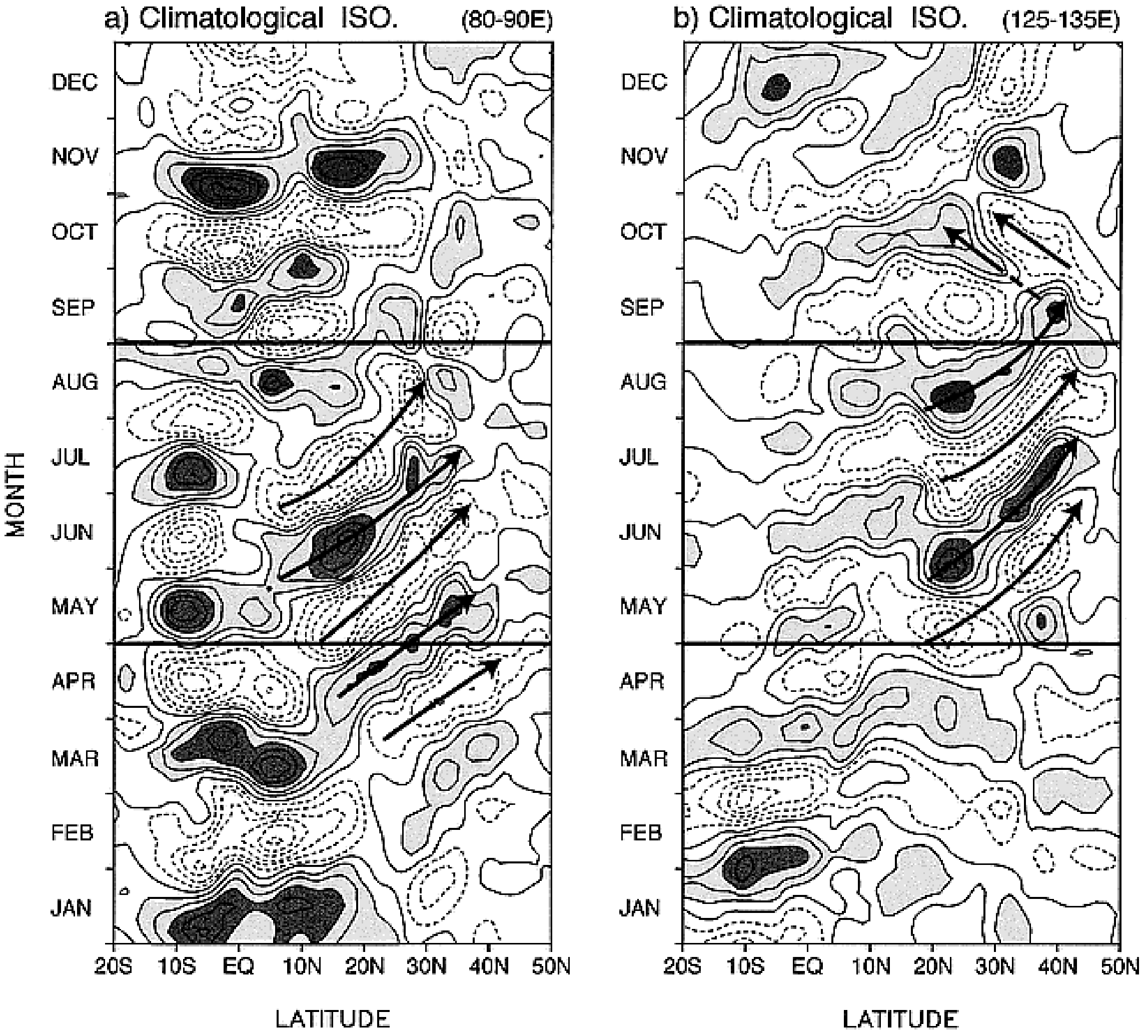


Figure 11. Hovmoeller diagrams of climatological intraseasonal component of cloud fraction along longitudinal bands of (a) 80°–90⁸E and (b) 125°– 135°E. Contour interval is 0.02. Light and dark shading indicate the cloud fractions between 0.02 and 0.06 and those greater than 0.06, respectively. From Kang *et al.* (1999).

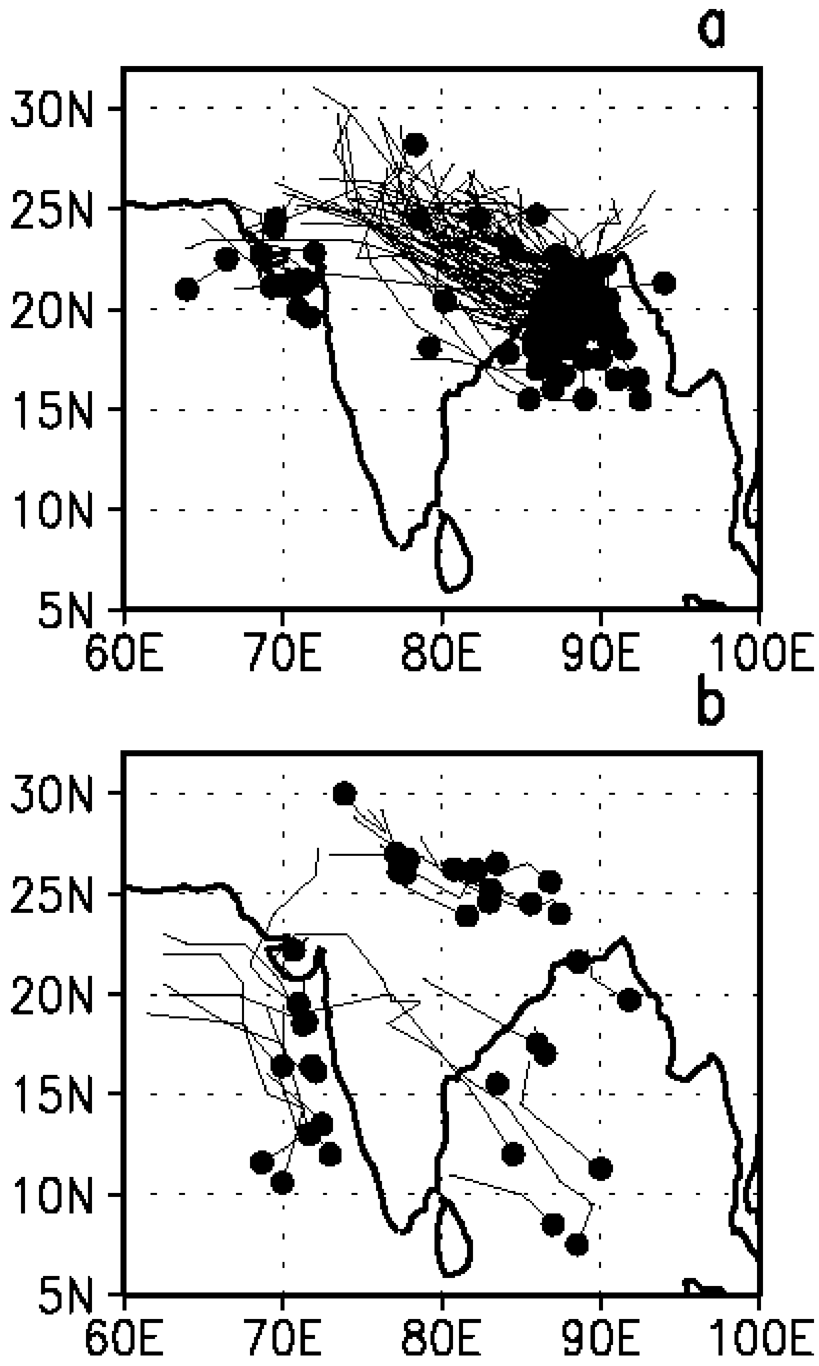


Figure 12. Tracks of low-pressure systems (LPS) for the period 1954–1983 during extreme phases of boreal summer ISO. (a) 'Active' ISO phase (analogous to 4th panel of Figure 6) and (b) 'Break' ISO phase (analogous to 2nd panel of Figure 6). Dark dots represent the genesis point of the LPS and their lines show the tracks. From Goswami *et al.* (2003).

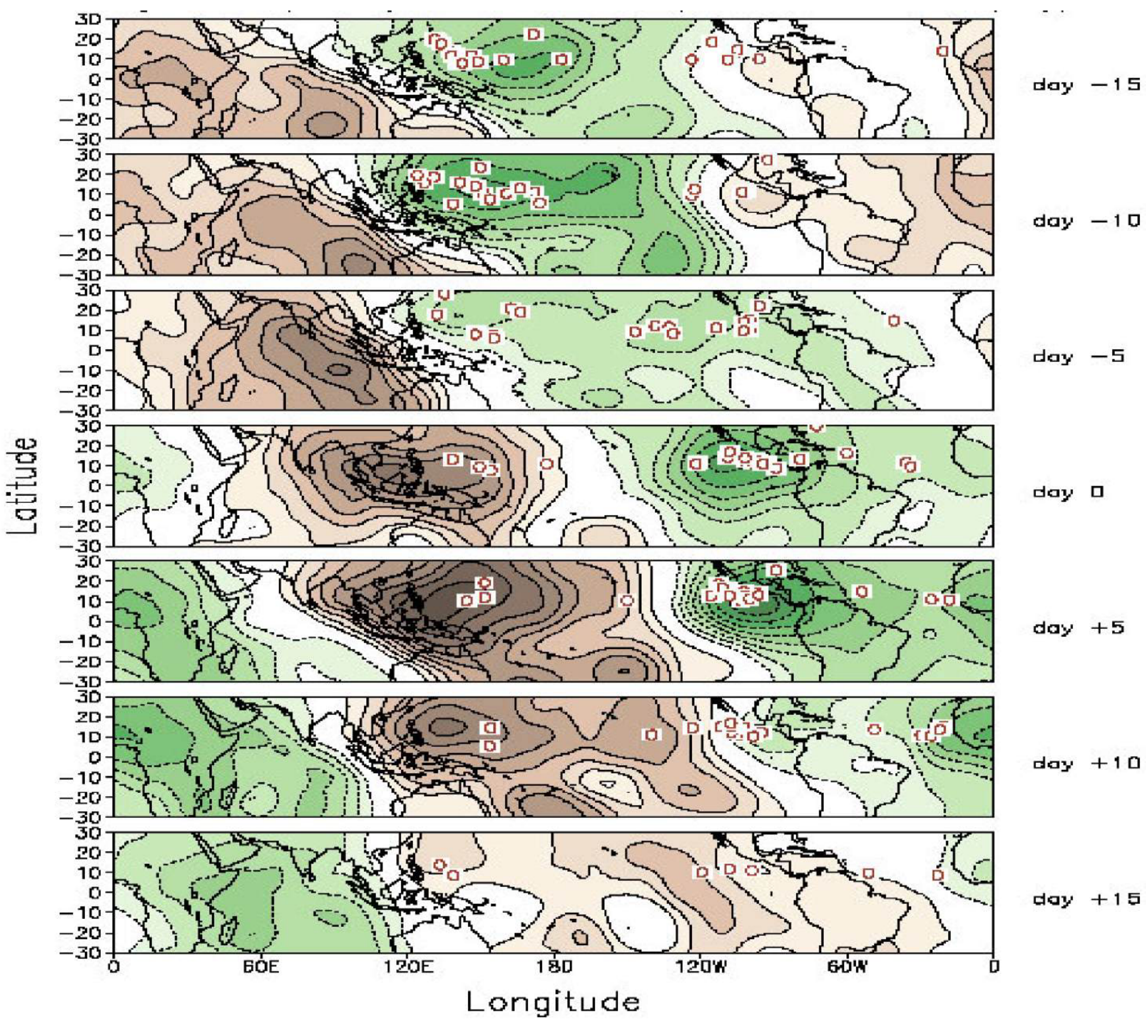


Figure 13. Composite evolution of 200 hPa velocity potential anomalies associated with the boreal summer ISO and points of origin of tropical systems that developed into hurricanes/typhoons. Note that panels 1-4 in Figure 6 roughly correspond to lags –5, +5, +15 and 15 days, respectively. The green (brown) shading roughly corresponds to regions where convection is favored (suppressed) as represented by 200-hPa velocity potential anomalies Composites are based on 21 ISO events, each considered over a 35 day period. Hurricane track data is for the period July-September for 1979-1997. Points of origin in each panel are for different storms – only those that occurred during the 21 selected ISO events. Contour interval is 0.5x106 m^2 s^{-1}, negative contours are dashed, and the zero contour is omitted for clarity. From Higgins *et al.*(2000).

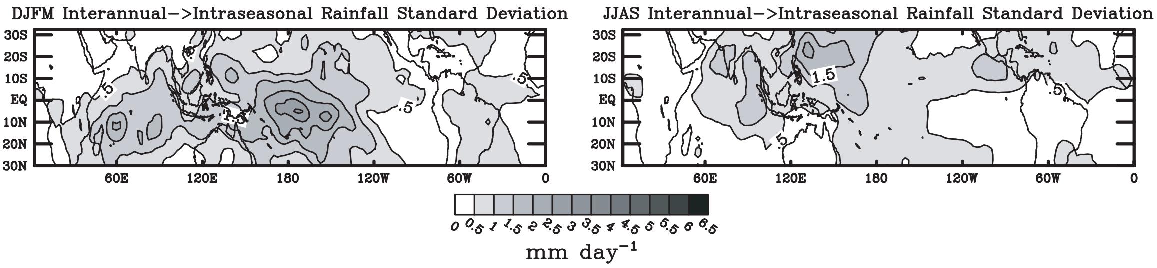


Figure 14. Interannual variation of intraseasonal rainfall variability. Rainfall data is based on pentad values of the satellite and in-situ merged CMAP product of Xie and Arkin (1997) from 1979 to 1999. In this case, the data were band-pass filtered, retaining periods between 30 and 90 days. The variance of these intraseasonal anomalies was computed separately for the each December-March (DJFM; left) and June-September (JJAS; right) period. The variance of these values [N=21 (20) for JJAS (DJFM)] was computed and is illustrated in terms of standard deviation.

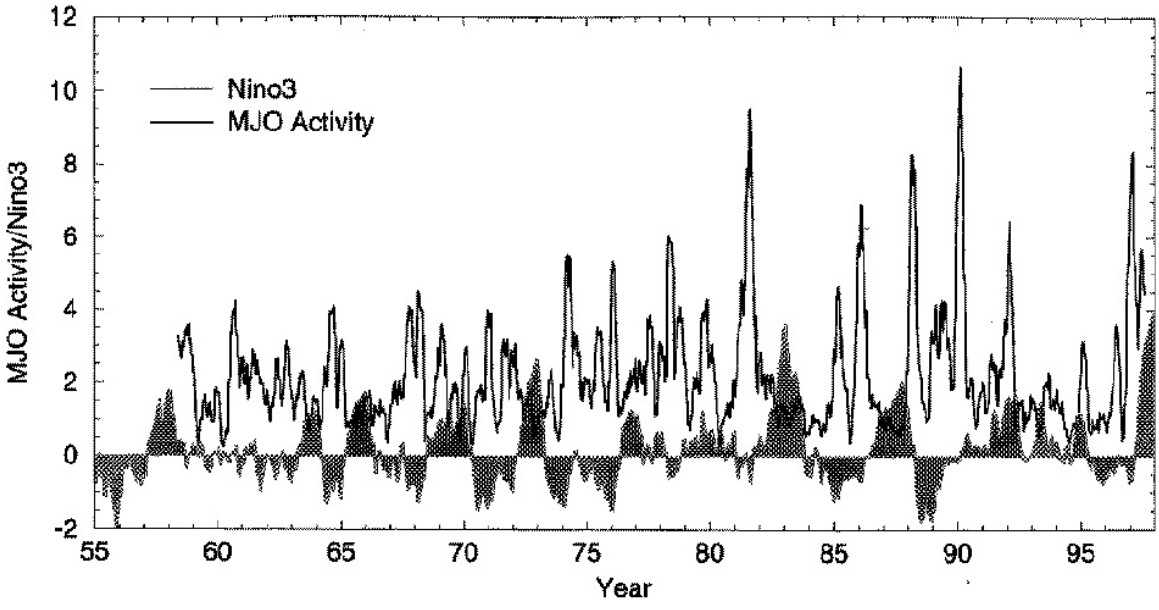


Figure 15. Index of MJO activity based on the variance of band-passed (10-90 days) upper-tropospheric zonal-mean zonal winds averaged between 10^{o}S-10^{-}N. Data are from the NCEP/NCAR Reanalysis (Kalnay *et al.*, 1996). A 100-day running mean has been applied to the variance time series. The lower shaded curve is the sea surface temperature anomaly (K) for the Nino3 region (5^{o}N-5^{o}S, 90^{p}W-150^{o}W). From Slingo *et al.* (1999).

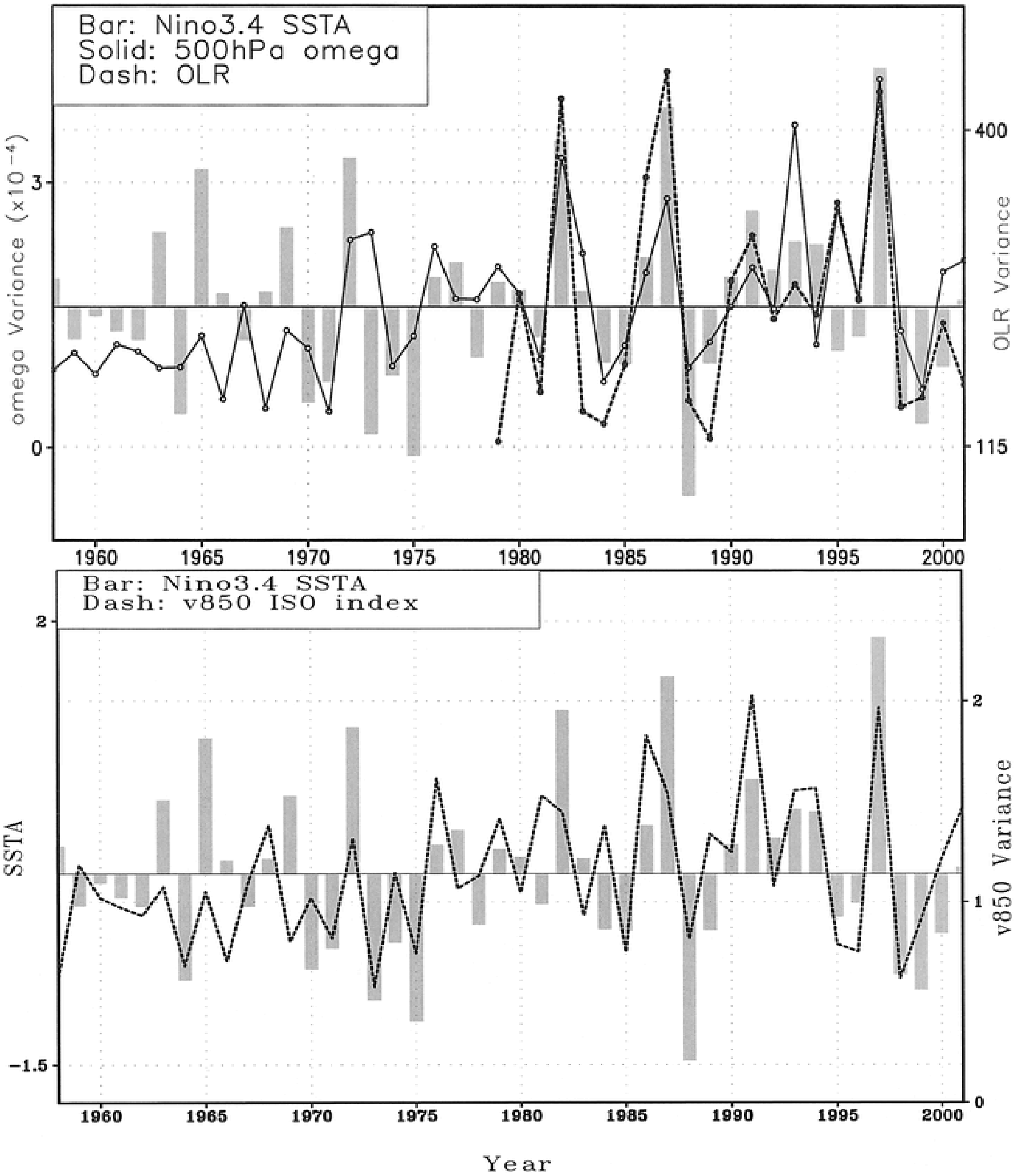


Figure 16. (upper) May–Jul 500-hPa vertical velocity MJO index (solid) during 1958–2001, the OLR MJO index (dash) during 1979–2001, and May–Jul mean Niño-3.4 SST anomaly (bar; see scale on lower plot) during 1958–2001. Vertical velocity and OLR data taken from the NCEP/NCAR Reanalysis (Kalnay *et al.*, 1996) and the OLR construction of Liebmann and Smith (1996), respectively. The MJO index is defined as the mean spectrum density for 20–50-day eastward-propagating wavenumber-1 (at 40°E–180°) anomalies averaged at 2.5°S–5°N for the vertical velocity and at 5°S–10°N for OLR. (lower) Similar to upper diagram, except for Jul–Oct mean Niño-3.4 SST anomaly (bar) and mean spectrum density of 10–50-day wavenumber-1–3 (at 100°E–180°) westward-propagating 850-hPa meridional wind anomaly (dash) at 5°–20°N.

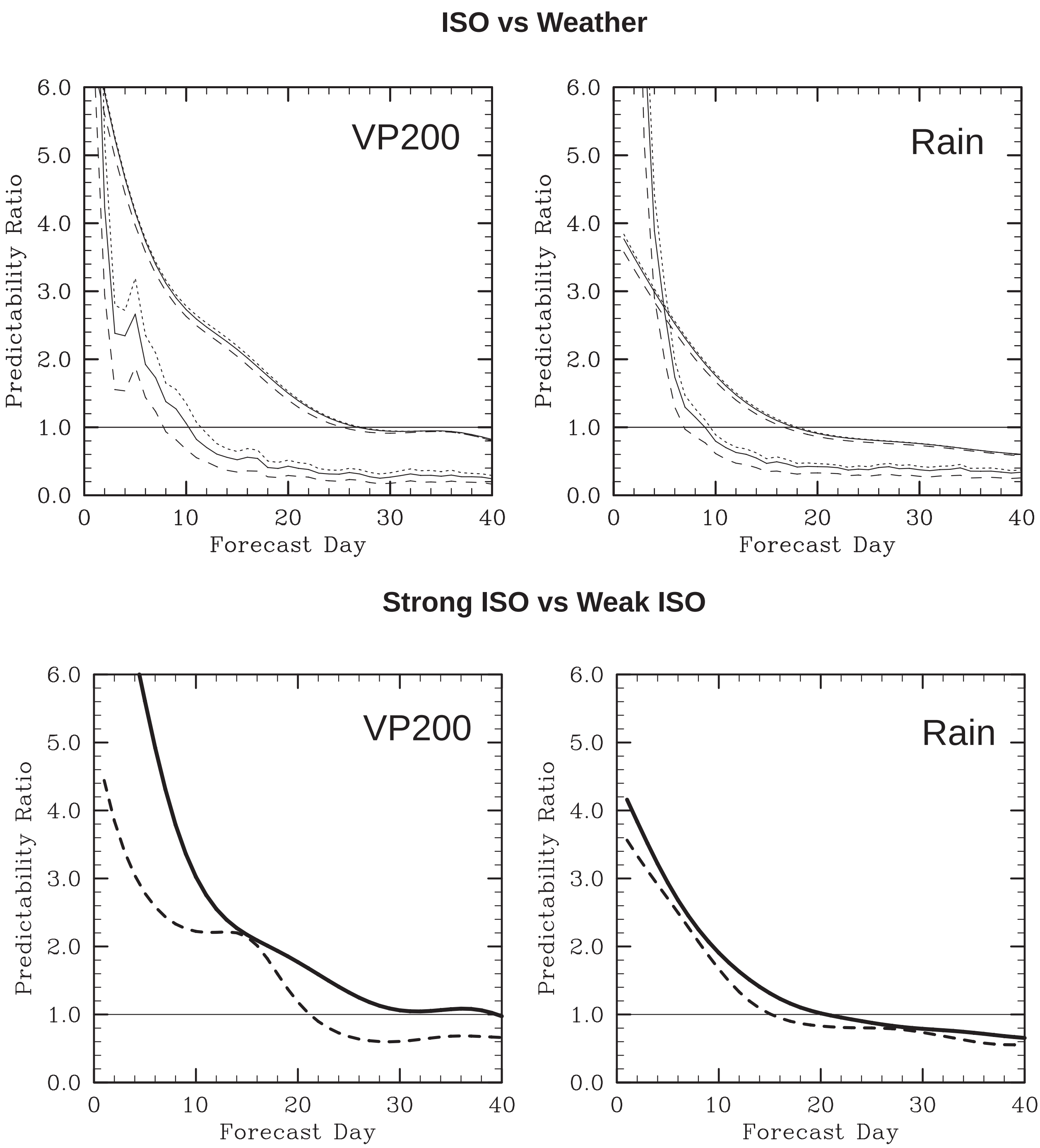
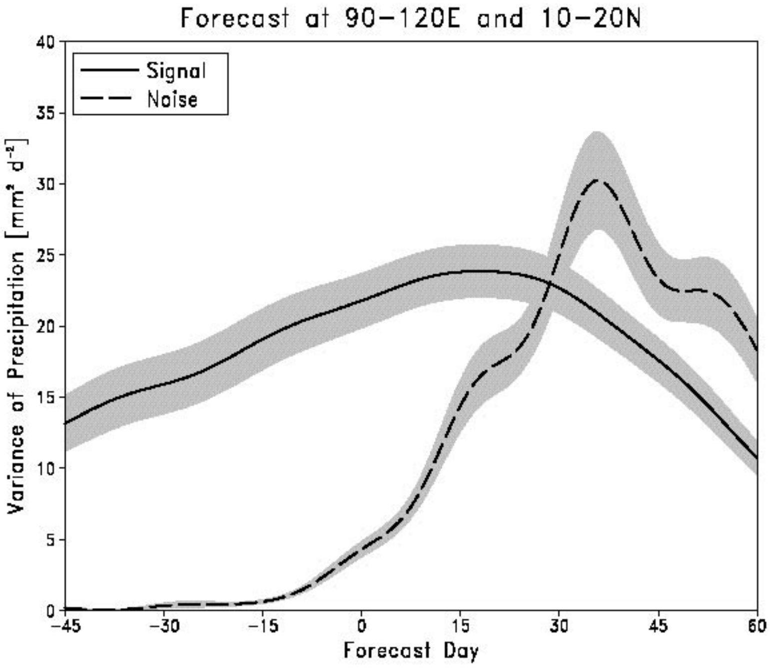


Figure 17. (top) ISO predictability versus lead time for 200 hPa velocity potential (VP200; left) and rainfall (right) averaged over the region 4°N-24°N and 72.5°E-132.5°E. The results are based on all 168 N.H. summertime cases from the dynamical forecasts. The rightmost (leftmost) group of lines are based on an evaluation using filtered (unfiltered) data to ascertain the predictability of the model's ISO (weather). (bottom) Same as (top), except that the solid (dashed) lines are based on forecasts using the 80 strongest (weakest) ISO cases.



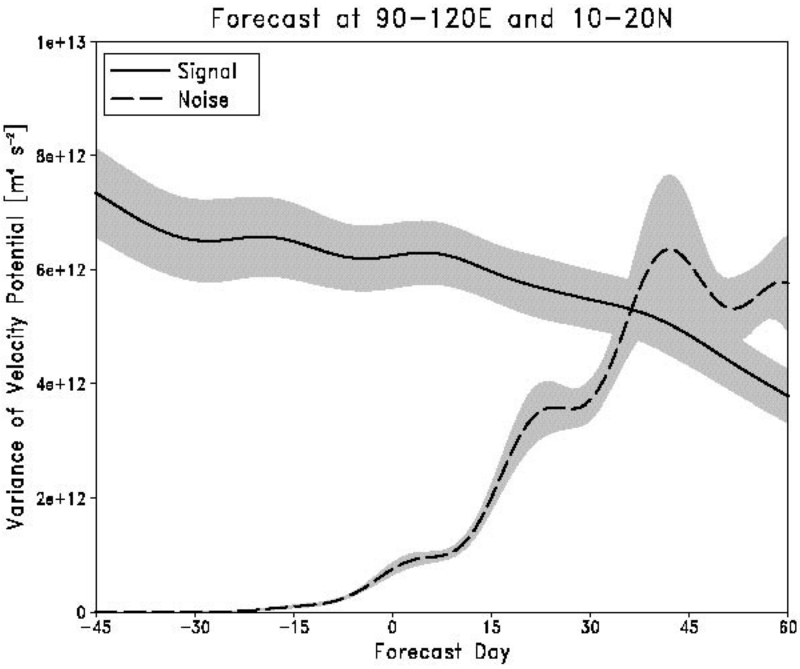


Figure 18. Signal-to-noise ratio of 30-90 day filtered precipitation (top) and 200 hPa velocity potential (bottom) predictions averaged over all four phases of three ISO events. Shadings represent the significance at the 95% interval based on all 12 forecasts. All values are averaged over the region 90 to 120 °E and 10 to 20°N. From Liess *et al.* (2004).

References

Alexander, G., R. Keshavamurty, R. C. U. De, *et al.*, 1978: Fluctuations of monsoon activity. *J. Met. Hydrol. Geophys.*, 29, 76–87.

Annamalai, H. and J. M. Slingo, 2001: Active/break cycles: diagnosis of the intraseasonal variability of the Asian Summer Monsoon. *Clim. Dyn.*, 18, 85-102.

Annamalai, H., J. M. Slingo, K. R. Sperber, *et al.*, 1999: The mean evolution and variability of the Asian summer monsoon: Comparison of ECMWF and NCEP-NCAR reanalyses. *Mon. Weather Rev.*, 127, 1157-1186.

Banerjee, A. K., P. N. Sen, and C. R. V. Raman, 1978: On foreshadowing southwest monsoon rainfall over India with mid-tropospheric circulation anomaly of April. *Indian J. Meteorol. Hydrol. Geophys.*, 29, 425-431.

Banerji, S. K., 1950: Methods of foreshadowing monsoon and winter rainfall in India. *Indian J. Meteorol. Geophysics*, 1, 4-14.

Berbery, E. H. and J. Noguespaegle, 1993: Intraseasonal Interactions between the Tropics and Extratropics in the Southern-Hemisphere. *J. Atmos. Sci.*, 50, 1950-1965.

Bhide, U. V., V. R. Mujamdar, S. P. Ghanekar, *et al.*, 1997: A diagnostic study on heat sources and moisture sinks in the monsoon trough area during active-break phases of the Indian summer monsoon, 1979. *Tellus Ser. A-Dyn. Meteorol. Oceanol.*, 49, 455-473.

Blanford, H. F., 1884: On the connection of the Himalaya snowfall with dry winds and seasons of droughts in India. *Proc. Roy. Soc. London*, 37, 3.

——, 1886: Rainfall of India. *Mem. India Meteorol. Dep.*, 2, 217–448.

Cadet, D., 1983: The Monsoon over the Indian-Ocean During Summer 1975 .2. Break and Active Monsoons. *Mon. Weather Rev.*, 111, 95-108.

Cadet, D. L., 1986: Fluctuations of Precipitable Water over the Indian-Ocean During the 1979 Summer Monsoon. *Tellus Ser. A-Dyn. Meteorol. Oceanol.*, 38, 170-177.

Cai, M., E. Kalnay, and Z. Toth, 2003: Bred vectors of the Zebiak-Cane model and their potential application to ENSO predictions. *J. Climate*, 16.

Chen, T.-C., 1987: 30-50 Day Oscillation of 200-mb Temperature and 850-mb Height during the 1979 Northern Summer. *Mon. Weather Rev.*, 115, 1589-1605.

Chen, T.-C. and M. Murakami, 1988: The 30–50-day variation of convective activity over the western Pacific Ocean with the emphasis on the northwestern region. *Mon. Wea. Rev*, 116, 892-906.

Chen, T. C. and J. C. Alpert, 1990: Systematic errors in the annual and intraseasonal variations of the planetary-scale divergent circulation in NMC medium-range forecasts. *J. Atmos. Sci.*, 118, 2607-2623.

Chen, T. C. and M. C. Yen, 1991: Intraseasonal Variations of the Tropical Easterly Jet During the 1979 Northern Summer. *Tellus Ser. A-Dyn. Meteorol. Oceanol.*, 43, 213-225.

Chen, T. C. and J. M. Chen, 1993: The 10-20-Day Mode of the 1979 Indian Monsoon - Its Relation with the Time-Variation of Monsoon Rainfall. *Mon. Weather Rev.*, 121, 2465-2482.

Chen, T. C. and J. R. Chen, 1995: An Observational Study of the South China Sea Monsoon During the 1979 Summer - Onset and Life-Cycle. *Mon. Weather Rev.*, 123, 2295-2318.

Chen, X. Y., H. J. Wang, F. Xue, *et al.*, 2001: Intraseasonal oscillation: the global coincidence and its relationship with ENSO cycle. *Adv. Atmos. Sci.*, 18, 445-453.

Dakshinarmuti, J. and R. N. Keshavamurty, 1976: On oscillations of period around one month in the Indian summer monsoon. *Indian J. Meteor. Hydrol. Geophys*, 27, 201-203.

Ding, Y.-H., 1992: Summer monsoon rainfall in China. *J. Meteor. Soc. Japan*, 70, 373–396.

Ferranti, L., T. N. Palmer, F. Molteni, *et al.*, 1990: Tropical-extratropical interaction associated with the 30-60-day oscillation and its impact on medium and extended range prediction. *J. Atmos. Sci.*, 47, 2177-2199.

Ferranti, L., J. M. Slingo, T. N. Palmer, *et al.*, 1997: Relations between interannual and intraseasonal monsoon variability as diagnosed from AMIP integrations. *Q. J. R. Meteorol. Soc.*, 123, 1323-1357.

Fink, A. and P. Speth, 1997: Some potential forcing mechanisms of the year-to-year variability of the tropical convection and its intraseasonal (25-70-day) variability. *Int. J. Climatol.*, 17, 1513-1534.

Flatau, M. K., P. J. Flatau, and D. Rudnick, 2001: The Dynamics of Double Monsoon Onsets. *J. Climate*, 14, 4130–4146.

Flatau, M. K., P. J. Flatau, J. Schmidt, *et al.*, 2003: Delayed onset of the 2002 Indian monsoon. *Geophys. Res. Lett.*, 30, art. no.-1768.

Fleming, R. J., T. M. Kaneshige, and W. E. McGovern, 1979: The Global Weather Experiment1. The Observational Phase Through the First Special Observing Period. *Bull. Amer. Meteorol. Soc.*, 60, 649-661.

Fu, X. H. and B. Wang, 2004: Differences of boreal summer intraseasonal oscillations simulated in an atmosphere-ocean coupled model and an atmosphere-only model. *J. Climate*, 17, 1263-1271.

Gadgil, S., 2003: The Indian monsoon and its variability. *Annu. Rev. Earth Planet. Sci.*, 31, 429-467.

Gadgil, S. and P. V. Joseph, 2003: On breaks of the Indian monsoon. *Proc. Indian Acad. Sci.-Earth Planet. Sci*, 112, 529-558.

Gadgil, S., J. Srinivasan, R. S. Nanjundiah, *et al.*, 2002: On forecasting the Indian summer monsoon: the intriguing season of 2002. *Curr. Sci.*, 83, 394-403.

Gill, A. E., 1980: Some simple solutions for heat-induced tropical circulation. *Q. J. R. Meteorol. Soc.*, 106, 447-462.

Goswami, B. N., 2004: South Asian Summer Monsoon. *Intraseasonal Variability of the Atmosphere-Ocean Climate System*, W. K. M. Lau and D. E. Waliser, Eds., Praxis.

Goswami, B. N. and R. S. A. Mohan, 2001: Intraseasonal oscillations and interannual variability of the Indian summer monsoon. *J. Climate*, 14, 1180-1198.

Goswami, B. N. and P. Xavier, 2003: Potential predictability and extended range prediction of Indian summer monsoon breaks. *Geophys. Res. Lett.,*, 30, 1966,doi:10.1029/2003GL017,810.

Goswami, B. N., D. Sengupta, and G. S. Kumar, 1998: Intraseasonal oscillations and interannual variability of surface winds over the Indian monsoon region. *Proc. Indian Acad. Sci.-Earth Planet. Sci*, 107, 45-64.

Goswami, B. N., R. S. Ajayamohan, P. K. Xavier, *et al.*, 2003: Clustering of synoptic activity by Indian summer monsoon intraseasonal oscillations. *Geophys. Res. Lett.*, 30, art. no.-1431.

Gray, W. M., 1978: Hurricanes: Their formation, structure and likely role in the tropical circulation. Meteorology over the Tropical Oceans. D. B. Show, Ed.,. *Royal Meteorological Society*, 155-218.

Gruber, A., 1974: Wavenumber-Frequency Spectra of Satellite-Measured Brightness in Tropics. *J. Atmos. Sci.*, 31, 1675-1680.

Gualdi, S., A. Navarra, and G. Tinarelli, 1999: The interannual variability of the Madden-Julian Oscillation in an ensemble of GCM simulations. *Clim. Dyn.*, 15, 643-658.

Gutzler, D. S., 1991: Interannual Fluctuations of Intraseasonal Variance of near- Equatorial Zonal Winds. *J. Geophys. Res.-Oceans*, 96, 3173-3185.

Han, W., P. J. Webster, R. B. Lukas, *et al.*, 2004: Impact of atmospheric intraseasonal atmospheric variability in the equatorial Indian Ocean: low-frequency rectification in equatorial surface current and transport. *J. Phys. Oceanogr.*, In Press.

Harr, P. A. and R. L. Elsberry, 1995: Large-scale circulation variability over the tropical western North Pacific, Part I: Spatial patterns and tropical cyclone characteristics. *Mon. Wea. Rev.*, 123, 1225-1246.

Hartmann, D. L. and E. D. Maloney, 2001: The Madden-Julian oscillation, barotropic dynamics, and North Pacific tropical cyclone formation. Part II: Stochastic barotropic modeling. *J. Atmos. Sci.*, 58, 2559-2570.

Hasselmann, K., 1988: Pips and Pops - the Reduction of Complex Dynamical-Systems Using Principal Interaction and Oscillation Patterns. *J. Geophys. Res.-Atmos.*, 93, 11015-11021.

Hastenrath, S., 1987: On the Prediction of India Monsoon Rainfall Anomalies. *J. Clim. Appl. Meteor.*, 26, 847-857.

Hendon, H. H. and M. L. Salby, 1994: The Life-Cycle of the Madden-Julian Oscillation. *J. Atmos. Sci.*, 51, 2225-2237.

Hendon, H. H., C. D. Zhang, and J. D. Glick, 1999: Interannual variation of the Madden-Julian oscillation during austral summer. *J. Climate*, 12, 2538-2550.

Hendon, H. H., B. Liebmann, M. Newman, *et al.*, 2000: Medium-range forecast errors associated with active episodes of the Madden-Julian oscillation. *Mon. Weather Rev.*, 128, 69-86.

Higgins, R. W., J. K. E. Schemm, W. Shi, *et al.*, 2000: Extreme precipitation events in the western United States related to tropical forcing. *J. Climate*, 13, 793-820.

Hoerling, M. P., J. W. Hurrell, and T. Y. Xu, 2001: Tropical origins for recent North Atlantic climate change. *Science*, 292, 90-92.

Hsu, H.-H. and C.-H. Weng, 2001: Northwestward Propagation of the Intraseasonal Oscillation in the Western North Pacific during the Boreal Summer: Structure and Mechanism. *J. Climate*, 14, 3834-3850.

Hsu, H.-H., C.-H. Weng, and C.-H. Wu, 2004: Contrasting Characteristics between the Northward and Eastward Propagation of the Intraseasonal Oscillation during the Boreal Summer. *J. Climate*, 17, 727-743.

Hsu, H. H., 2004: East Asian Monsoon. *Intraseasonal Variability of the Atmosphere-Ocean Climate System*, W. K. M. Lau and D. E. Waliser, Eds., Praxis.

Jagannathan, P., 1960: Seasonal Forecasting in India, A Review. Meteorological Office, Poona, India, 79 pp.

Jones, C., D. E. Waliser, J. K. E. Schemm, *et al.*, 2000: Prediction skill of the Madden and Julian Oscillation in dynamical extended range forecasts. *Clim. Dyn.*, 16, 273-289.

Jones, C., D. E. Waliser, K. M. Lau, *et al.*, 2004a: The Madden-Julian Oscillation and its Impact on Northern Hemisphere Weather Predictability. *Mon. Wea. Rev.*, 132, 1462-1471.

Jones, C., L. M. V. Carvalho, R. W. Higgins, *et al.*, 2003: Climatology of Tropical Intraseasonal Convective Anomalies: 1979-2002. *J. Climate*, 17, 523-539.

——, 2004b: Statistical Forecast Skill of Tropical Intraseasonal Convective Anomalies. *J. Climate*, In Press.

Kalnay, E., M. Kanamitsu, R. Kistler, *et al.*, 1996: The NCEP/NCAR 40-year reanalysis project. *Bull. Amer. Meteorol. Soc.*, 77, 437-471.

Kalnay, E. R., W. Balgovind, D. Chao, *et al.*, 1983: Documentation of the GLAS fourth order general circulation model, Volume 1. NASA Tech. Memo. No. 86064, NASA Goddard Space Flight Center, Greenbelt, MD.

Kang, I., S. An, C. Joung, *et al.*, 1989: 30-60 day oscillation appearing in climatological variation of outgoing longwave radiation around East Asia during summer. *J Korean Meteorol Soc*, 25, 149-160.

Kang, I. S., C. H. Ho, Y. K. Lim, *et al.*, 1999: Principal modes of climatological seasonal and intraseasonal variations of the Asian summer monsoon. *Mon. Weather Rev.*, 127, 322-340.

Kemball-Cook, S. and B. Wang, 2001: Equatorial waves and air-sea interaction in the Boreal summer intraseasonal oscillation. *J. Climate*, 14, 2923-2942.

Keppenne, C. L. and M. Ghil, 1992: Adaptive Filtering and Prediction of the Southern Oscillation Index. *J. Geophys. Res.-Atmos.*, 97, 20449-20454.

Kessler, W., 2004: ISV in the Oceans. *Intraseasonal Variability of the Atmosphere-Ocean Climate System*, W. K. M. Lau and D. E. Waliser, Eds., Praxis.

Kessler, W. S., 2001: EOF representations of the Madden-Julian oscillation and its connection with ENSO. *J. Climate*, 14, 3055-3061.

Kessler, W. S. and R. Kleeman, 2000: Rectification of the Madden-Julian oscillation into the ENSO cycle. *J. Climate*, 13, 3560-3575.

Krishna Kumar, K., M. K. Soman, and K. Rupa Kumar, 1995: Seasonal forecasting of Indian summer monsoon rainfall. *Weather*, 50, 449-467.

Krishnamurti, T. N. and H. N. Bhalme, 1976: Oscillations of a Monsoon System .1. Observational Aspects. *J. Atmos. Sci.*, 33, 1937-1954.

Krishnamurti, T. N. and D. Subrahmanyam, 1982: The 30-50 Day Mode at 850 Mb During Monex. *J. Atmos. Sci.*, 39, 2088-2095.

Krishnamurti, T. N. and S. Gadgil, 1985: On the Structure of the 30 to 50 Day Mode over the Globe During Fgge. *Tellus Ser. A-Dyn. Meteorol. Oceanol.*, 37, 336-360.

Krishnamurti, T. N., D. K. Oosterhof, and A. V. Mehta, 1988: Air Sea Interaction on the Time Scale of 30 to 50 Days. *J. Atmos. Sci.*, 45, 1304-1322.

Krishnamurti, T. N., S. O. Han, and V. Misra, 1995: Prediction of the Dry and Wet Spell of the Australian Monsoon. *Int. J. Climatol.*, 15, 753-771.

Krishnamurti, T. N., M. Subramaniam, D. K. Oosterhof, *et al.*, 1990: Predictability of Low-Frequency Modes. *Meteorol. Atmos. Phys.*, 44, 63-83.

Krishnamurti, T. N., M. Subramaniam, G. Daughenbaugh, *et al.*, 1992: One-Month Forecasts of Wet and Dry Spells of the Monsoon. *Mon. Weather Rev.*, 120, 1191-1223.

Krishnan, R. and S. V. Kasture, 1996: Modulation of low frequency intraseasonal oscillations of northern summer monsoon by El Nino and southern oscillation (ENSO). *Meteorol. Atmos. Phys.*, 60, 237-257.

Kung, E. C. and T. A. Sharif, 1980: Regression Forecasting of the Onset of the Indian-Summer Monsoon with Antecedent Upper Air Conditions. *J. Appl. Meteorol.*, 19, 370-380.

——, 1982: Long-Range Forecasting of the Indian-Summer Monsoon Onset and Rainfall with Upper Air Parameters and Sea-Surface Temperature. *J. Meteorol. Soc. Jpn.*, 60, 672-681.

Lau, K. M. and P. H. Chan, 1986: Aspects of the 40-50 Day Oscillation During the Northern Summer as Inferred from Outgoing Longwave Radiation. *Mon. Weather Rev.*, 114, 1354-1367.

Lau, K. M. and T. J. Phillips, 1986: Coherent Fluctuations of Extratropical Geopotential Height and Tropical Convection in Intraseasonal Time Scales. *J. Atmos. Sci.*, 43, 1164-1181.

Lau, K. M. and P. H. Chan, 1988: Intraseasonal and Interannual Variations of Tropical Convection - a Possible Link between the 40-50 Day Oscillation and Enso. *J. Atmos. Sci.*, 45, 506-521.

Lau, K. M. and F. C. Chang, 1992: Tropical Intraseasonal Oscillation and Its Prediction by the NMC Operational Model. *J. Climate*, 5, 1365-1378.

Lau, K. M., G. J. Yang, and S. H. Shen, 1988: Seasonal and Intraseasonal Climatology of Summer Monsoon Rainfall over East-Asia. *Mon. Weather Rev.*, 116, 18-37.

Lau, W. K. M., 2004: ENSO Connections. *Intraseasonal Variability of the Atmosphere-Ocean Climate System*, W. K. M. Lau and D. E. Waliser, Eds., Praxis.

Lau, W. K. M. and D. E. Waliser, Eds., 2004: *Intraseasonal Variability of the Atmosphere-Ocean Climate System*. Praxis, Submitted pp.

Lawrence, D. M. and P. J. Webster, 2001: Interannual variations of the intraseasonal oscillation in the south Asian summer monsoon region. *J. Climate*, 14, 2910-2922.

Li, T. M. and B. Wang, 1994: The Influence of Sea-Surface Temperature on the Tropical Intraseasonal Oscillation - a Numerical Study. *Mon. Weather Rev.*, 122, 2349-2362.

Liebmann, B. and D. L. Hartmann, 1984: An Observational Study of Tropical Midlatitude Interaction on Intraseasonal Time Scales During Winter. *J. Atmos. Sci.*, 41, 3333-3350.

Liebmann, B. and C. A. Smith, 1996: Description of a complete (interpolated) outgoing longwave radiation dataset. *Bull. Amer. Meteorol. Soc.*, 77, 1275-1277.

Liebmann, B., H. H. Hendon, and J. D. Glick, 1994: The Relationship between Tropical Cyclones of the Western Pacific and Indian Oceans and the Madden-Julian Oscillation. *J. Meteorol. Soc. Jpn.*, 72, 401-412.

Liess, S., D. E. Waliser, and S. Schubert, 2004: Predictability studies of the intraseasonal oscillation with ECHAM. *J. Atmos. Sci.*, Submitted.

Lo, F. and H. H. Hendon, 2000: Empirical extended-range prediction of the Madden-Julian oscillation. *Mon. Weather Rev.*, 128, 2528-2543.

Lorenc, A. C., 1984: The Evolution of Planetary-Scale 200-Mb Divergent Flow During the Fgge Year. *Q. J. R. Meteorol. Soc.*, 110, 427-441.

Lorenz, E. N., 1965: A study of the predictability of a 28-variable atmospheric model. *Tellus*, 17, 321–333.

Madden, R. and P. Julian, 2004: Historical Perspective. *Intraseasonal Variability of the Atmosphere-Ocean Climate System*, W. K. M. Lau and D. E. Waliser, Eds., Praxis.

Madden, R. A. and P. R. Julian, 1971: Detection of a 40-50 day oscillation in the zonal wind in the tropical Pacific. *J. Atmos. Sci.*, 28, 702-708.

——, 1994: Observations of the 40-50-Day Tropical Oscillation - a Review. *Mon. Weather Rev.*, 122, 814-837.

Maloney, E. D. and D. L. Hartmann, 2000a: Modulation of eastern North Pacific hurricanes by the Madden-Julian oscillation. *J. Climate*, 13, 1451-1460.

——, 2000b: Modulation of hurricane activity in the Gulf of Mexico by the Madden-Julian oscillation. *Science*, 287, 2002-2004.

Maloney, E. D. and M. J. Dickinson, 2003: The intraseasonal oscillation and the energetics of summertime tropical western North Pacific synoptic-scale disturbances. *J. Atmos. Sci.*, 60, 2153-2168.

Matsumoto, J., 1992: The seasonal changes in Asian and Australian monsoon regions. *J. Meteor. Soc. Japan*, 70, 257–273.

Matsuno, T., 1966: Quasi-Geostrophic Motions in the Equatorial Area. *J. Met. Soc. Japan*, 44, 25-43.

McBride, J. L., 1995: Tropical cyclone formation. Chap. 3, Global Perspectives on Tropical Cyclones, Tech. Doc. WMO/TD No. 693, World Meteorological Organization, Geneva, Switzerland, 63-105.

Mo, K. C., 2000: The association between intraseasonal oscillations and tropical storms in the Atlantic basin. *Mon. Weather Rev.*, 128, 4097-4107.

——, 2001: Adaptive filtering and prediction of intraseasonal oscillations. *Mon. Weather Rev.*, 129, 802-817.

Mooley, D. A., B. Parthasarathy, and G. B. Pant, 1986: Relationship between Indian-Summer Monsoon Rainfall and Location of the Ridge at the 500-Mb Level Along 75-Degrees-E. *J. Clim. Appl. Meteor.*, 25, 633-640.

Murakami, M., 1977: Spectrum Analysis Relevant to Indian Monsoon. *Pure Appl. Geophys.*, 115, 1145-1166.

Murakami, T., 1976a: Cloudiness fluctuations during the summer monsoon. *J. Meteor. Soc. Japan*, 54.

——, 1976b: Analysis of summer monsoon fluctuations over India. *J. Meteor. Soc. Japan*, 54.

——, 1987: Intraseasonal Atmospheric Teleconnection Patterns during the Northern Hemisphere Summer. *Mon. Weather Rev.*, 115, 2133-2154.

Murakami, T. and T. Nakazawa, 1985: Tropical 45 Day Oscillations During the 1979 Northern Hemisphere Summer. *J. Atmos. Sci.*, 42, 1107-1122.

Murakami, T., L.-X. Chen, and A. Xie, 1986: Relationship among Seasonal Cycles, Low-Frequency Oscillations, and Transient Disturbances as Revealed from Outgoing Longwave Radiation Data. *Mon. Weather Rev.*, 114, 1456-1465.

Myers, D. and D. E. Waliser, 2003: Three dimensional water vapor and cloud variations associated with the Madden-Julian Oscillation during Northern Hemisphere winter. *J. Climate*, 16, 929-950.

NA, 1978: Fgge - Global Weather Experiment. *Meteorological Magazine*, 107, 225-232.

Nakazawa, T., 1986: Intraseasonal variations of OLR in the tropics during the FGGE year. *J. Meteor. Soc. Japan*, 70.

——, 1992: Seasonal phase lock of intraseasonal variation during the Asian summer monsoon. *J Meteorol Soc Japan*, 70, 257-273.

Newman, M., P. D. Sardeshmukh, C. R. Winkler, *et al.*, 2003: A study of subseasonal predictability. *Mon. Weather Rev.*, 131, 1715-1732.

Normand, C. W. B., 1953: Monsoon seasonal forecasting. *Q. J. R. Meteorol. Soc.*, 79, 463-473.

Parthasarathy, B., A. A. Munot, and D. R. Kothawale, 1988: Regression-Model for Estimation of Indian Foodgrain Production from Summer Monsoon Rainfall. *Agric. For. Meteorol.*, 42, 167-182.

——, 1994: All-India Monthly and Seasonal Rainfall Series - 1871-1993. *Theor. Appl. Climatol.*, 49, 217-224.

Raghavan, K., 1973: Break-Monsoon over India. *Mon. Weather Rev.*, 101, 33-43.

Rajeevan, M., D. S. Pai, and V. Thapliyal, 1998: Spatial and temporal relationships between global land surface air temperature anomalies and Indian summer monsoon rainfall. *Meteorol. Atmos. Phys.*, 66, 157-171.

Ramanadh, R., P. V. Rao, and J. K. Patnaik, 1973: Break in Indian Summer Monsoon. *Pure Appl. Geophys.*, 104, 635-647.

Ramaswamy, C., 1962: Breaks in the Indian Summer Monsoon as a Phenomenon of Interaction between the Easterly and the Sub-Tropical Westerly Jet Streams. *Tellus*, 14, 337-349.

Salby, M. L. and H. H. Hendon, 1994: Intraseasonal Behavior of Clouds, Temperature, and Motion in the Tropics. *J. Atmos. Sci.*, 51, 2207-2224.

Sardeshmukh, P. D. and B. J. Hoskins, 1988: The Generation of Global Rotational Flow by Steady Idealized Tropical Divergence. *J. Atmos. Sci.*, 45, 1228-1251.

Schemm, J. E., H. v. d. Dool, and S. Saha, 1996: A Multi-Year DERF Experiment at NCEP. *11th Conference on Numerical Weather Prediction, August 19-13*, Norfolk, Virginia, 47-49.

Schubert, S., R. Dole, H. v. d. Dool, *et al.*, 2002: Proceedings from a workshop on "Prospects for improved forecasts of weather and short-term climate variability on subseasonal (2 week to 2 month) time scales",16-18 April 2002, Mitchellville, MD, NASA/TM 2002-104606, vol. 23, 171 pp.

Shinoda, T. and H. H. Hendon, 2002: Rectified wind forcing and latent heat flux produced by the Madden-Julian Oscillation. *J. Climate*, 23, 3500-3508.

Shukla, J., 1985: Predictability. *Adv. Geophys.*, 28B, 87-122.

Shukla, J. and D. A. Paolino, 1983: The Southern Oscillation and Long-Range Forecasting of the Summer Monsoon Rainfall over India. *Mon. Weather Rev.*, 111, 1830-1837.

Shukla, J. and D. A. Mooley, 1987: Empirical Prediction of the Summer Monsoon Rainfall over India. *Mon. Weather Rev.*, 115, 695-703.

Sikka, D. R., 1980: Some Aspects of the Large-Scale Fluctuations of Summer Monsoon Rainfall over India in Relation to Fluctuations in the Planetary and Regional Scale Circulation Parameters. *Proc. Indian Acad. Sci.-Earth Planet. Sci*, 89, 179-195.

Slingo, J. M., D. P. Rowell, K. R. Sperber, *et al.*, 1999: On the predictability of the interannual behaviour of the Madden-Julian Oscillation and its relationship with El Nino. *Q. J. R. Meteorol. Soc.*, 125, 583-609.

Slingo, J. M., K. R. Sperber, J. S. Boyle, *et al.*, 1996: Intraseasonal oscillations in 15 atmospheric general circulation models: Results from an AMIP diagnostic subproject. *Clim. Dyn.*, 12, 325-357.

Sperber, K. R., J. M. Slingo, and H. Annamalai, 2000: Predictability and the relationship between subseasonal and interannual variability during the Asian summer monsoon. *Q. J. R. Meteorol. Soc.*, 126, 2545-2574.

Sperber, K. R., J. M. Slingo, P. M. Inness, *et al.*, 1997: On the maintenance and initiation of the intraseasonal oscillation in the NCEP/NCAR reanalysis and in the GLA and UKMO AMIP simulations. *Clim. Dyn.*, 13, 769-795.

Straub, K. H. and G. N. Kiladis, 2003: Interactions between the boreal summer intraseasonal oscillation and higher-frequency tropical wave activity. *Mon. Weather Rev.*, 131, 945-960.

Sud, Y. C. and G. K. Walker, 1992: A review of recent research on improvement of physical parameterizations in the GLA GCM. *In Physical Processes in Atmospheric Models*, D. R. S. a. S. S. Singh, Ed., Wiley Eastern Ltd., 422-479.

Sui, C. H. and K. M. Lau, 1992: Multiscale Phenomena in the Tropical Atmosphere over the Western Pacific. *Mon. Weather Rev.*, 120, 407-430.

Tanaka, M., 1992: Intraseasonal oscillation and onset and retreat dates of the summer monsoon over east, southeast Asia and the western Pacific region using GMS high cloud amount. *J. Meteor. Soc. Japan*, 70, 613-629.

Teng, H. Y. and B. Wang, 2003: Interannual variations of the boreal summer intraseasonal oscillation in the Asian-Pacific region. *J. Climate*, 16, 3572-3584.

Thapliyal, V. and S. M. Kulshrestha, 1992: Recent models for long-range forecasting of Southwest monsoon rainfall in India. *Mausum*, 43, 239-248.

Toth, Z. and E. Kalnay, 1993: Ensemble forecasting at NMC: The generation of perturbations. *Bull. Amer. Meteorol. Soc.*, 74, 2330-2371.

Ueda, H., T. Yasunari, and R. Kawamura, 1995: Abrupt Seasonal Change of Large-Scale Convective Activity over the Western Pacific in the Northern Summer. *J. Meteorol. Soc. Jpn.*, 73, 795-809.

Vautard, R. and M. Ghil, 1989: Singular Spectrum Analysis in Nonlinear Dynamics, with Applications to Paleoclimatic Time-Series. *Physica D*, 35, 395-424.

vonStorch, H. and J. Xu, 1990: Principal oscillation pattern analysis of the 30- to 60-day oscillation in the tropical troposphere. *Clim. Dyn.*, 4, 175-190.

Waliser, D., Z. Zhang, K. M. Lau, *et al.*, 2001: Interannual Sea Surface Temperature Variability and the Predictability of Tropical Intraseasonal Variability. *J. Atmos. Sci.*, 58, 2595-2614.

Waliser, D., S. Schubert, A. Kumar, *et al.*, 2003a: Proceedings from a workshop on "Modeling, Simulation and Forecasting of Subseasonal Variability", 4-5 June 2003, University of Maryland, College Park, Maryland, NASA/TM 2003-104606, vol. 25, 67 pp.

Waliser, D. E., 2004: Predictability and Forecasting Tropical Intraseasonal Variability. *Intraseasonal Variability of the Atmosphere-Ocean Climate System*, W. K. M. Lau and D. E. Waliser, Eds., Praxis.

Waliser, D. E. and K. Weickmann, 2004: An Experimental MJO Prediction Project. *Bull. Amer. Meteorol. Soc.*, In Preparation.

Waliser, D. E., K. M. Lau, and J. H. Kim, 1999a: The influence of coupled sea surface temperatures on the Madden-Julian oscillation: A model perturbation experiment. *J. Atmos. Sci.*, 56, 333-358.

Waliser, D. E., R. Murtugudde, and L. Lucas, 2003b: Indo-Pacific Ocean Response to Atmospheric Intraseasonal Variability. Part I: Austral Summer and the Madden-Julian Oscillation. *J. Geophys. Res.-Oceans*, 108, 10.1029/2002JC001620.

——, 2004: Indo-Pacific Ocean Response to Atmospheric Intraseasonal Variability. Part II: Boreal Summer and the Intraseasonal Oscillation. *J. Geophys. Res.-Oceans*, In Press.

Waliser, D. E., C. Jones, J. K. E. Schemm, *et al.*, 1999b: A statistical extended-range tropical forecast model based on the slow evolution of the Madden-Julian oscillation. *J. Climate*, 12, 1918-1939.

Waliser, D. E., K. M. Lau, W. Stern, *et al.*, 2003c: Potential Predictability of the Madden-Julian Oscillation. *Bull. Amer. Meteor. Soc.*, 84, 33-50.

Waliser, D. E., W. Stern, S. Schubert, *et al.*, 2003d: Dynamic Predictability of Intraseasonal Variability Associated with the Asian Summer Monsoon. *Quart. J. Royal Meteor. Soc.*, 129, 2897-2925.

Waliser, D. E., K. Jin, I. S. Kang, *et al.*, 2003e: AGCM Simulations of Intraseasonal Variability Associated with the Asian Summer Monsoon. *Clim. Dyn.*, 21, 423-446.

Walker, G. T., 1923: Correlation in seasonal variations of weather, VII. A preliminary study of world weather. *Mem. Indian Meteorol. Dept.*, 24, 75-131.

——, 1924: Correlation in seasonal variations of weather IV: A further study of world weather. *Mem. Indian Meteorol. Dept.*, 24, 275-332.

——, 1928: World Weather, III. *Mem. R. Meteorol. Soc.*, 4, 97-106.

——, 1933: Seasonal weather and its prediction. British Association for Advancement of Science. Rep. 103. [Reprinted Annual Smithsonian Institute for 1935, 117-138.], 25-44. pp.

Walker, G. T. and E. W. Bliss, 1932: World Weather, V. *Mem. R. Meteorol. Soc.*, 4, 53-84.

Wang, B. and H. Rui, 1990: Synoptic Climatology of Transient Tropical Intraseasonal Convection Anomalies - 1975-1985. *Meteorol. Atmos. Phys.*, 44, 43-61.

Wang, B. and X. S. Xie, 1996: Low-frequency equatorial waves in vertically sheared zonal flow .1. Stable waves. *J. Atmos. Sci.*, 53, 449-467.

Wang, B. and X. H. Xu, 1997: Northern hemisphere summer monsoon singularities and climatological intraseasonal oscillation. *J. Climate*, 10, 1071-1085.

Wang, B. and X. S. Xie, 1997: A model for the boreal summer intraseasonal oscillation. *J. Atmos. Sci.*, 54, 72-86.

Wang, B. and LinHo, 2002: Rainy season of the Asian-Pacific summer monsoon. *J. Climate*, 15, 386-398.

Webster, P. J. and S. Yang, 1992: Monsoon and Enso - Selectively Interactive Systems. *Q. J. R. Meteorol. Soc.*, 118, 877-926.

Webster, P. J. and C. Hoyos, 2003: Forecasting monsoon rainfall and river discharge variability on 20-25 day time scales. *Bull. Amer. Meteorol. Soc.*, In Press.

Webster, P. J., V. O. Magana, T. N. Palmer, *et al.*, 1998: Monsoons: Processes, predictability, and the prospects for prediction. *J. Geophys. Res.-Oceans*, 103, 14451-14510.

Weickmann, K. M., 1983: Intraseasonal Circulation and Outgoing Longwave Radiation Modes During Northern Hemisphere Winter. *Mon. Weather Rev.*, 111, 1838-1858.

Weickmann, K. M., G. R. Lussky, and J. E. Kutzbach, 1985: Intraseasonal (30-60 Day) Fluctuations of Outgoing Longwave Radiation and 250-Mb Stream-Function During Northern Winter. *Mon. Weather Rev.*, 113, 941-961.

Wheeler, M. and G. N. Kiladis, 1999: Convectively coupled equatorial waves: Analysis of clouds and temperature in the wavenumber-frequency domain. *J. Atmos. Sci.*, 56, 374-399.

Wheeler, M. and K. M. Weickmann, 2001: Real-time monitoring and prediction of modes of coherent synoptic to intraseasonal tropical variability. *Mon. Wea. Rev.*, 129, 2677-2694.

Wheeler, M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction. *Mon. Weather Rev.*, In Press.

Wheeler, M. C. and J. L. McBride, 2004: Australian-Indonesian Monsoon Region. *Intraseasonal Variability of the Atmosphere-Ocean Climate System*, W. K. M. Lau and D. E. Waliser, Eds., Praxis.

Winkler, C. R., M. Newman, and P. D. Sardeshmukh, 2001: A linear model of wintertime low-frequency variability. Part I: Formulation and forecast skill. *J. Climate*, 14, 4474-4494.

Wu, R. and B. Wang, 2001: Multi-stage onset of the summer monsoon over the western North Pacific. *Clim. Dyn.*, 17, 277-289.

Wu, R. G. and B. Wang, 2000: Interannual variability of summer monsoon onset over the western North Pacific and the underlying processes. *J. Climate*, 13, 2483-2501.

Xie, P. P. and P. A. Arkin, 1997: Global precipitation: A 17-year monthly analysis based on gauge observations, satellite estimates, and numerical model outputs. *Bull. Amer. Meteorol. Soc.*, 78, 2539-2558.

Xie, X. S. and B. Wang, 1996: Low-frequency equatorial waves in vertically sheared zonal flow .2. Unstable waves. *J. Atmos. Sci.*, 53, 3589-3605.

Yasunari, T., 1979: Cloudiness fluctuations associated with the Northern Hemisphere summer monsoon. *J. Met. Soc. Japan*, 57, 227-242.

——, 1980: A quasi-stationary appearance of the 30-40 day period in the cloudiness fluctuations during the summer monsoon over India. *J. Met. Soc. Japan*, 59, 336-354.

——, 1981: Structure of an Indian summer monsoon system with around 40-day period. *J. Meteorol. Soc. Jpn.*, 59, 336– 354.

Zangvil, A., 1975: Temporal and Spatial Behavior of Large-Scale Disturbances in Tropical Cloudiness Deduced from Satellite Brightness Data. *Mon. Weather Rev.*, 103, 904-920.

Zheng, Y., D. E. Waliser, W. F. Stern, *et al.*, 2004: The Role of Coupled Sea Surface Temperatures in the Simulation of the Tropical Intraseasonal Oscillation. *J. Climate*, In Press.

Zveryaev, I., 2002: Interdecadal changes in the zonal wind and the intensity of intraseasonal oscillations during boreal summer Asian monsoon. *Tellus Ser. A-Dyn. Meteorol. Oceanol.*, 54, 288-298.